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**KENYA TANGANYIKA UGANDA AND ZANZIBAR**



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# THE EAST AFRICAN AGRICULTURAL JOURNAL

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## SOIL MOISTURE

Two articles in this number deal with the utilization of undeveloped areas. J. Glover, in a sketch of the problems of the semi-arid areas, shows that control of vegetation and selection of crops that make only a small demand on the water supply are likely to offer the best means of developing land with low and irregular rainfall. In general, his suggestions mean that in an area with an average rainfall of 20 inches, crop selection and control of the natural vegetation should aim at using only, say, 10 inches per annum, which would provide a small surplus in years of average rainfall, after allowing for normal evaporation and run-off. This surplus would offset a year with somewhat less than average rainfall, and might also provide a subsurface water supply for man and animals. It is interesting to note how successful the experimental work in the drier areas of the United States has been, but it would be dangerous to apply on a large scale the results of work in other countries, or even in other parts of the same country, without preliminary measurements followed by field trials.

While the provision of domestic water is of extreme importance in the utilization of the drier areas it is by no means an insoluble problem, for one inch of rain on an acre of land means 22,000 gallons of water, it is estimated that the seasonal run-off from a bare plot one-fortieth of an acre in size, under an average annual rainfall of 27 inches, if effectively stored would be sufficient to supply a native family for a whole year.

F. Grundy's article on water conservation, also published in this number, summarizes the factors involved in storing water for domestic use, and therefore it has a practical bearing on the subject raised by Glover. It also emphasizes that water conservation does not merely mean digging a hole in the ground and letting water run into it; the hydrology of that area must be studied in order that an assured supply will be available for storage. If, therefore, a large sum of money were suddenly made available for water conservation in order to increase the carrying capacity of an area as regards man and animals, there might not be sufficient data on rainfall, evaporation, stream flow and soil properties to guide the water engineer in laying down suitable catchments or dams.

One reason why the semi-arid areas have not been investigated more fully as a source of relief from the overcrowding of the more favoured agricultural areas is that, until comparatively recently, it was assumed that moist soil, if exposed to the high temperatures and drying winds of the tropics, would lose all its moisture to a considerable depth in a short time. It was thought that the subsoil moisture was drawn up to the surface by capillary force, and the structure of a soil, as regards water movement, was likened to a bundle of fine tubes, the thickness of which varied according to the mechanical composition of the soil. Thus, in a coarse sandy soil the "tubes" were presumed to be wide, and the rapid drainage was accounted for by the obvious fact that water will drain through a wide tube faster than through a narrow one. On the other hand, the capillary force in a wide tube is less than in a narrow one; this was supposed to be the reason why sandy soils dry out quickly in the surface layers, since there was not sufficient "pull" to bring water to the surface from the subsoil. Heavy clay soils, with narrow "tubes", showed the opposite effects, slow drainage and slow drying out, since the capillary pull to the surface was much greater than in sandy soils.

This simple theory of the movement of moisture in soil provided a convenient explanation of a number of facts and practices in agriculture, and it was not until comparatively recently that it was challenged, and finally disproved, by physicists. A short article by Dr. B. A. Keen of Rothamsted Experimental Station which was reprinted in this

Journal (Vol. IX, 1943, page 107) gives an account of the effect on cultivation methods which is resulting from the change in ideas on soil moisture. The new theory can be generalized in Dr. Keen's own words—the water "stays put" if it can. It does not move upward like water in a tube or oil in a lamp wick; it will be evaporated from the surface soil by sun and wind, but the subsurface water will not rise to replace that lost by evaporation. Thus, in general, a *bare* moist soil subjected to drying sun and wind will dry out only to a depth of a few inches. If the soil is carrying vegetation of any kind, the plant roots will tap the lower moist layers, and the soil will gradually dry out to a considerable depth. That is why bare fallow can be used in dry areas to conserve moisture for the following crop.

The principles of "dry farming" depend on this, and the alternation of crop and bare fallow means that rain from two wet seasons is used. The danger of bare fallow is that erosion and leaching are liable to occur during the rainy season, but this can be reduced by allowing weed growth during wet weather and by clearing the ground at the end of the rains. The native practice of merely scratching the surface with a crude form of plough has the great advantage that it does not disturb the subsurface soil and cause it to dry out rapidly. It must be remembered, however, that the native normally cultivates his land very shortly before planting, and the frequent condemnation of the modern plough in native agriculture is based on the assumption that it would be used in the same way as the shallow native plough. In areas of irregular rainfall any cultivation immediately before planting, other than scratching the surface, would mean that unless the rains came gently but steadily the soil would either be washed away or dried out. On the other hand, by leaving undisturbed a very compact subsoil, roots may be hindered in their movement, and only a relatively shallow layer of moist soil may be used by the plant. In theory, therefore, deep cultivation every few years, preferably with a ripper which will not turn up the raw subsoil, should improve the permeability of the soil for both water and roots, but this should be done some time before a crop is planted in order to let the soil settle before the cropping season. After that, very shallow ploughing in order to destroy weeds and to prepare the seed bed would avoid the danger of allowing the subsoil moisture to evaporate. The crop roots would thus have a much larger volume of moist soil at their disposal, as compared with the shallow layer available to roots that have difficulty in penetrating a hard, raw subsoil.

The chief difference, as regards water supply, between heavy clay and light sandy soils is that the clay particles have a spongy structure which absorbs water, whereas the particles of a sandy soil are nearly all impervious to water, which can therefore be stored only between the grains. Both Glover and Grundy mention the field capacity and wilting point of soils, the differences between these two being the water available to the plant. In a heavy soil the spongy clay particles exert a strong "pull" on the water, and wilting occurs when the moisture remaining in the soil is held so firmly by the clay particles that the plant roots cannot pull it away from them. There may be a considerable amount of water in the soil at this state—over 15 per cent in some heavy soils—but so far as the plant is concerned the soil is dry. On the other hand, a heavy soil is able to hold more water than a sandy soil without being waterlogged (the field capacity). Grundy gives a table showing the relationship between moisture equivalent (almost the same as field capacity) and the wilting point in a range of soils, and it can be seen that the lighter the soil the less available moisture it contains, although the amount of "bound water" in a clay is much higher than in a sand. Yet, because of the high percolation rate of sandy soils, water penetrates rapidly to the subsoil where it is safe from the effects of evaporation, while clay soils, with slow penetration of water, are much more liable to lose water by run-off and evaporation.

When post-war schemes come into effect, funds may be available for large-scale development of sparsely populated areas. There may be a certain amount of administrative impatience because sufficient scientific information is not already available to guarantee success. Nevertheless the application of fundamental theory to practice can do much to guide the policy, so long as it is realized that success cannot be assured without extensive preliminary observations over a long period.

D.W.D.

## CORRECTION

In the article on golf greens and lawns in the October, 1945, number of this Journal, on page 98, column 2, line 17, the sentence should read: "The correct brush is about 2 *feet* long and has steel wire bristles". *Editor.*

# SOME PROBLEMS OF SEMI-ARID AREAS

By J. Glover, Plant Physiologist, Amani

(*Received for publication on 11th October*, 1945)

The semi-arid areas might roughly be defined as those lands which lie between the deserts and the zones where the normal rainfall is sufficient to give good crops and supply domestic water for man and animals throughout the year. They are sometimes described as areas of marginal rainfall. Much of the land in East Africa is of this type. Gillman [1] has pointed out that one-fifth of Tanganyika Territory, with good or fair water supplies supports five-sixths of the population, while another one-fifth, precariously watered, supports the remainder. In Gillman's opinion lack of permanent water is primarily responsible for the emptiness of the remaining three-fifths of the territory.

Somewhat surprisingly, the semi-arid areas often have a high average annual rainfall. In fact it may be as high, or higher, than that which is adequate elsewhere. It is therefore worth while looking more closely at the rainfall in one of these areas. The first figure shows the average rainfall over a 17-year period in one East African semi-arid area together with the yearly totals.

It can be seen that average rainfall is very misleading. The yearly totals can vary between 18 to 40 inches, but these, too, are deceptive. The second figure shows the monthly rainfall over more than two years, and it is representative of most years.

It is obvious that there are well-marked alternating wet and dry seasons within the year and that more than 90 per cent of the rain falls between the end of November and the beginning of May, the hottest months of the year south of the equator. But this, too, is also deceptive, for most of the rain in the wet season falls in torrential downpours. It has been recorded that as much as three inches has fallen in little more than one hour. The average soil, no matter how well prepared, will not absorb and hold that amount, or even smaller amounts when delivered at such a rate. It is apparent, therefore, that there will be considerable run-off and evaporation, two important sources of loss to soil and plant. The run-off contributes to the rapid rise of the watercourses and it will carry away soil, forming miniature erosion gullies, while evaporation will be fairly rapid between showers. It is therefore obvious that we cannot trust the monthly totals to represent, even roughly, the amount of water that might be stored in the soil.

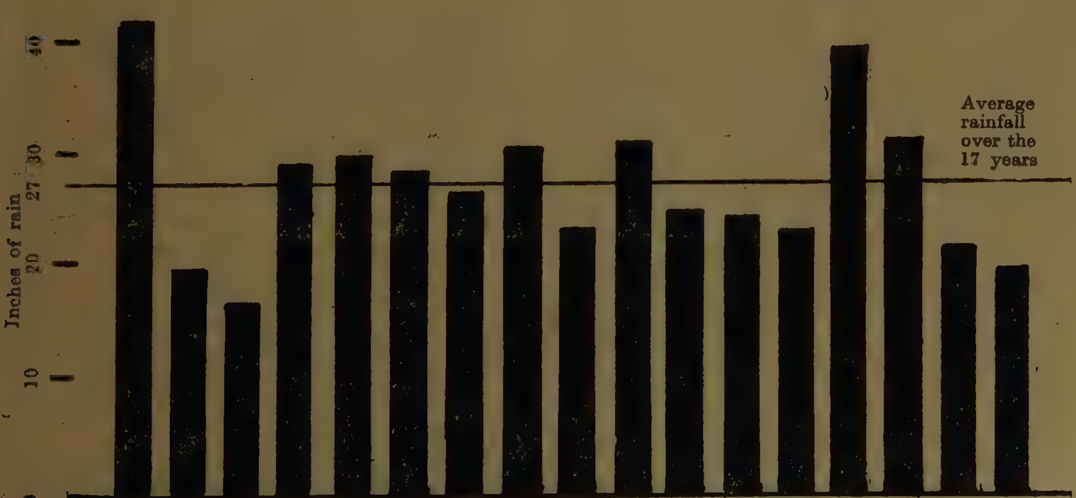


FIG. 1—The yearly total of rainfall over 17 successive years. Each column represents the total for one year.

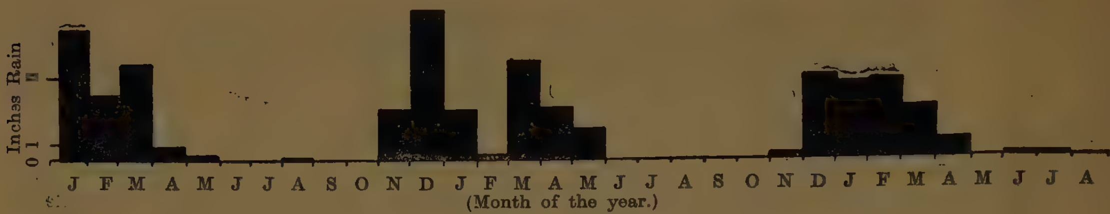


FIG. II—The seasonal distribution of the rain.

As the water runs off the streams will rise and fall and have an intermittent flow. The soil may hold some of the water, but while this can be utilized by plants, it is not of much use for man and animals who require a regular supply of water in bulk throughout the year. Therefore, by far the greatest problem of the semi-arid areas is the provision of domestic water.

The first thing to do, then, is to establish "permanent" water in the semi-arid area. There are at least two ways in which this might be done. One is a direct method, the other indirect.

*The direct method* may be any of the following:—

(*a*) Controlled catchment areas.

(*b*) Irrigation from a permanent stream outside the area.

(*c*) Wells tapping underground water.

A controlled catchment area is basically a bare piece of sloping ground arranged so that all the rain falling on it is run off into storage tanks. Its efficiency has been described by Staples [2] who, referring to the area the rainfall of which we have already discussed, says, "Yet if the seasonal run-off from a bare plot one-eightieth of an acre in size had been entirely conserved during the past four years, it would have been sufficient to supply the average domestic consumption of a Gogo family for at least two years!" This means that an area of say 35 ft. by 35 ft. or slightly over one-fortieth of an acre would maintain a regular supply for one year. The result is not surprising when we remember that one inch of rain is the equivalent of 100 tons, or over 22,000 gallons, on every acre. It should be noted that Staples says "a bare plot" not a specially prepared impervious layer which would be expected to give more efficient conservation.

The second and third of the above methods involve the transport of water from where it is abundant to the distributing centre or system. Neither is a method of conservation. The first involves a slight conservation for domestic use. None is a means of building up soil moisture and increasing the "permanent" water.

*The indirect method.*

When rain falls on the earth it can run off, evaporate, or penetrate the soil. The different proportions are determined by the intensity of the rain, the climate, and the structure of the soil and the topography. It is the water penetrating the soil which is the most important. When it is in sufficient quantity it can go deeper and deeper until, after satisfying the water requirements of the zones through which it passes, it reaches layers where it can move moderately freely sideways as well as downwards. Examples of such are strata of gravel, sand or rock brash. The water moving in these layers replenishes the underground water which feeds the wells, springs and streams of the neighbourhood. It may also travel long distances to be utilized elsewhere. It would seem, therefore, that if we could increase the penetration of the rain and its percolation through the soil we could increase the underground reserves of water and supply increased amounts to the tapping points.

We could start this by controlling the run-off. There should be little difficulty about this, for Staples says that "It may be taken that any one of the types of vegetation in the Territory (Tanganyika), if not greatly impaired, is capable of preventing serious direct run-off and erosion". The vegetative cover will also help to shade the soil and may thereby slow down evaporation. All this seems within easy possibility but unfortunately it introduces a further complication. This is the fact that plants transpire and can remove from the upper soil layers considerable quantities of water. Thus although by growing a good vegetation cover we may conserve the rain in one way, we shall dissipate it in another. Some idea of the quantities of water involved is shown by Staples. He measured the amounts of water given off by samples of the following

types: grassland, deciduous thicket and riverine forest. He then calculated that in 120 days (four months approximately):—

Grassland could possibly use up 22 inches of rain.

Deciduous thicket could possibly use up 38 inches of rain.

Riverine forest could possibly use up 90 inches of rain.

He goes on to say that if either of the first two vegetation types was allowed free growth, grassland is the only one which may not be capable of using the whole of the rainfall in the semi-arid area, in a normal season. He found some support for these views by actually measuring the amount of water in the soil under both grassland and thicket. When he did this he found that the rainfall which penetrated the soil below the thicket "was used up astonishingly quickly by the vegetation, so that none appeared to be available for spring formation". He also found that the water penetrated deepest under the grass cover.

These experiments point the way to the possible improvement of the water supplies of the semi-arid area. If we can grow a useful crop which makes the minimum demand on the soil water then we might expect to increase the amounts which percolate through the soil to underground water. The following is a brief explanation of the main points involved.

There are a number of different measurements of soil water of which two are of considerable practical value. They are—

(1) *the field capacity.*—This is the amount of water, expressed as a percentage of the weight of oven-dry soil, which is held in a soil when excess water has drained away under the force of gravity and when the downward movement of water is at a very slow rate;

(2) *the wilting point.*—This is the amount of water present in a soil when plants wilt and die. It, too, is expressed as a percentage of the oven-dry weight of the soil. There may be a considerable amount of water stored in the soil at this point but because the force which holds it in the soil almost counterbalances that exerted by the root-system, the movement of the water into the roots is so reduced that the plant dies.

It can be seen that "field capacity" is of considerable importance. If the amount of water in the top layers of soil exceeds the field capacity then water is available for drainage downwards, but if the soil underneath is water-logged no drainage is possible. If the lower layer is at field capacity then water moves further downwards; if, however, it has been dried to less than field capacity then the excess water from the uppermost layer will be held until the "dry" layer approaches field capacity. In general, water cannot percolate through a layer of soil until that layer has been soaked to field capacity. Thus in order that rain may percolate through to the water table the soil between the surface and the water table must be at or about "field capacity". There are of course exceptions to this rule. A very deeply cracked soil or one which contains deep channels left by decaying roots may allow water to penetrate past the "dry" soil layers and so reach the water table more quickly.

A few days after rain the average soil reaches its field capacity because of drainage. After this and before more rain or irrigation, the plant must draw on the stored reserve of water in the soil. This is the amount of water between the field capacity and the wilting point. For example, a layer of dry soil one acre in extent and one foot deep weighs about 1,780 tons. If its field capacity is 35 per cent and its wilting point 20 per cent then the water available to the plants is 15 per cent of its dry weight or 267 tons. In practice, when this is the top foot of soil, less water will be available to the plant for some will evaporate before the roots can draw on it.

Consider now two types of plants A and B with similar root-systems growing in uniform soil whose water content is at field capacity. If A transpires more water than B under the same climatic conditions then before the next rain falls the soil under A will lose more water than that under B. More water is therefore required to recharge the soil under A to its field capacity than that under B. If sufficient water is applied to the soil under A to recharge it to its field capacity then a similar amount applied to the soil under B would recharge it above its field capacity; thus some will be available for percolation. The soil under B has therefore a better chance of being recharged above its field capacity if there is only a little rain. A practical example may clarify this.

Assume that on one acre of soil there are 5,000 plants of type A each consuming 4 lb. of water per day, while on a similar acre there are 5,000 plants of type B each consuming only 2 lb. of water per day. If at first the soil is soaked to its field capacity and there follows a 20-day interval without rain or irrigation then at the end of this time the plants A would have removed 400,000 lb. (178 tons) of water from their acre of soil while those of B only 200,000 lb. (89 tons). Since one inch of rain on one acre is the equivalent of some 100 tons of water it can be seen that the A plants have removed some 1.8 inches of rain from the soil while those of B have removed only some 0.9 inch in the same time. If at the end of the 20 days drought one inch of rain falls it can be seen that in theory the soil under B would be recharged to 0.1 inch of rain above its field capacity, that is some 10 tons of water would be available for percolation from that acre of ground. The same amount of rain falling on the soil with a deficiency of 1.8 inches of rain would not saturate it to field capacity and no water would be available for percolation.

No matter which method, or combination of methods, is used to increase the water supply in the semi-arid areas the treatment of the existing vegetation must be carefully considered. If the indirect method is adopted then it would apparently be better to replace deciduous thicket by grassland since Staples has calculated that grassland consumes less water than thicket. However, we know very little about the thicket and its role in the life and fertility of the soil. It has proved that it can survive there so it may be needed as one stage in the rotation of vegetation. If this is the case then only part of the land can be used productively at one time. Another problem concerns the most suitable plants to replace the existing vegetation. Obviously the first thing to do is to study the experiments that have been made elsewhere and try to benefit by the experience of others. If we think of trying grain crops in the semi-arid areas we would naturally look for one that demands the least water from the soil. The water requirements of many plants has been measured, for what matters is not the actual rainfall, as that depends on a number of local factors, but the amount of water the plant needs to produce a unit of dry matter. In spite of the fact that the work has been carried out in different areas there is close agreement in the results. For example, the water requirement of maize was measured over six seasons in Colorado [3] and it was found that the plant needed an average of 358 pounds of water to make one pound of dry matter, and in South Africa, at Pretoria, it was found that over four seasons the plant required an average of 356 pounds to produce the same result [4].

In discussing grain crops it is easier to visualize their water needs if we measure them as the amounts of water required to make 1 lb. of grain. Consider the three important warm-country food-plants: millets, sorghums and maize. Figures III, IV and V show the amounts of water required by the three plants in one of the dry lands of North America. The average monthly maximum shade temperatures there, in the growing season, were somewhat similar to those of the hot months of some semi-arid areas of East Africa. The minimum shade temperatures during the same period were, however, somewhat lower than those of our semi-arid area. Figure III shows the average amount of water needed to produce one pound of grain in each of the three types.

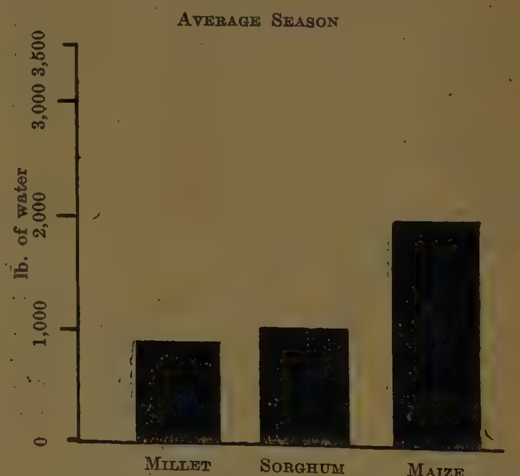


FIG. III—Pounds of water required to make one pound of grain.

It should be noted that these are average values. We have already seen that averages may not give a true picture of rainfall so it is better also to consider the water requirements of these plants in extreme seasons. Figures IV and V show the water requirements of similar plants in an unusually hot dry year and in an unusually cool damp year.

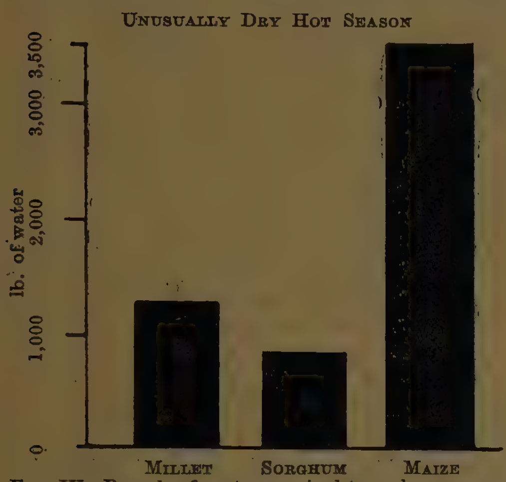


Fig. IV—Pounds of water required to make one pound of grain in an unusually dry hot season.

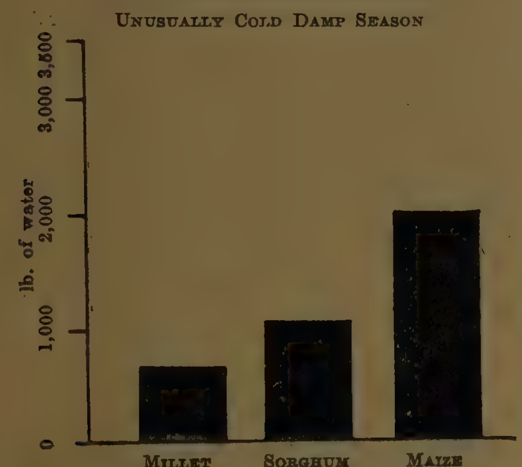


Fig. V—Pounds of water required to make one pound of grain in an unusually cold damp season.

We can see from these that, in general, maize demands more water to produce a pound of grain than either millet or sorghum; and that sorghum is apparently fairly steady in its demands for water. It apparently does not want more in a dry year than do millet and maize. If, therefore, we consider trying to conserve soil moisture and grow a food crop, all other things being equal, we might try to grow millets and sorghums before testing maize. We would also try to find amongst the different varieties of each, those which needed the least water to produce the most grain, for there are differences in the water requirements even among the varieties of each crop plant.

To some extent this has been done in the United States of America. There, according to Martin [5], sorghums could only be grown successfully when the mean July temperature was at least 75°F. and the average precipitation at least 17 inches. But new varieties developed by the plant breeders can mature at a mean July temperature of 70°F. and average annual rainfall of 15 inches, and also mature more quickly. The practical value of the sorghums in that country is obvious when we consider that between 1919 and 1940 some five to nine million acres of all types of sorghum were harvested annually [6]. Of this total, some two to six million acres were devoted to the grain sorghums, while the sweet sorghums which average about 100 gallons of syrup per acre, provided some 25–30 million gallons of syrup. Sorghum syrup production ranks equal third with that of molasses after sugar cane and corn syrups in the United States [7]. Further, sorghums are also of importance in the control of wind erosion. Bennett [8] says "Before native grass can be grown successfully on most of the blowland of the Southern Plains the soil blowing must be checked. Usually the land is stabilized by a dense cover of sorghum prior to planting".

These figures assume an added importance when it is realized that most of this sorghum is produced in the relatively small area of the southern Great Plains which cover the western parts of Texas, Oklahoma and Kansas together with eastern New Mexico. These areas are semi-arid and sorghum is grown there "largely or entirely because of the greater ability of sorghums to produce a crop under dry, hot conditions" [5]. In these dry areas the total annual rainfall varies greatly from year to year and generally three-fourths of it falls in the growing season April to September. During this rainy season temperatures are high and humidities are often low; in addition there are frequent clear skies and high winds. All these contribute to the rapid evaporation of that portion of the rain which does not penetrate more than a few inches into the soil. Table I shows the annual yields of a grain sorghum variety in one of these dry areas. They were recorded by members of the United States Department of Agriculture [9] and represent only a very small portion of a comprehensive series of larger experiments. The evaporation during the growing seasons (April to September) ranged between 51 and 67 inches. It should be noted that this figure expresses the depth of water which would be evaporated from a free water surface and it does not represent the true rate of evaporation from the soil. It is, however, a guide to the dryness of the atmosphere. During the period of the water-requirement experiments made at

Pretoria and described earlier the evaporation from a free water surface in the neighbourhood was between 54 and 63 inches per year.

TABLE I

| Rainfall in Inches | | Yield/Acre | |
|---|---|---|---|
| Annual | Seasonal April-Sept. | Threshed grain in 56-lb. bushels | Air-dry forage in tons |
| 20·84 | 17·41 | 40·3 | 4·11 |
| 15·79 | 11·51 | 15·2 | 1·67 |
| 4·68 | 4·25 | 0·0 | 0·0 |
| 12·35 | 6·88 | 3·0 | 1·12 |
| 34·01 | 23·14 | 48·0 | 3·49 |
| 21·29 | 14·63 | 41·5 | 3·08 |
| 11·11 | 8·58 | 20·9 | 1·75 |

The failure of the crop in the third year, when the plants received only 4½ inches of rain in the growing season, is not surprising. It is remarkable, however, that in the succeeding year when the seasonal rain was less than seven inches some grain and forage, even if only a little, were successfully harvested. So far only grain sorghums which produce small amounts of fodder have been considered. There are also forage sorghums and intermediate types. The sorghums are of African origin and their drought resistance is well known; they are, therefore, of possible value for the semi-arid areas of East Africa. It would be unwise, however, to rush into the large-scale cultivation of such plants until experiment has shown how they, with others, can be fitted into the economy, particularly the water economy, of such areas, for in the United States it has been found that in drought years sorghums live and continue to grow under climatic conditions which would kill maize, and thereby they continue to remove water from the soil. This would seem to be detrimental to the conservation of water and it certainly must be carefully investigated. However, it may not be a serious difficulty, for agronomists who studied soil moisture under semi-arid conditions at five stations in the Great Plains [10] say that "Water charge and discharge are much the same under sod as under continuous grain production, although available water is removed completely to a lower depth under sod than under grain, probably because of the deep-rooted perennial plants in the native sod. Where fallow or a cultivated crop enters into the cropping system the subsoil is wetter than under sod in most cases". They concluded that "Breaking up the upland sod in the Great Plains has not decreased the quantity of water in the subsoil.", and "The net result of the production of annual crops in the semi-arid section has been an increase rather than a decrease in subsoil water". These conclusions may not apply to the East African semi-arid areas, but they are an indication that annual crops may not be a serious danger to their water economy.

The foregoing sketch is only intended to stimulate interest in the semi-arid areas. If we are to make better use of our land resources we must tackle this problem with vigour and a clear understanding of the end in view. It is, therefore, obvious that everyone, including Africans, must play a part in the discussion and that no single and perhaps biased opinion should carry disproportionate weight in the planning until the views of others are made clear. For example, the writer is at present of the opinion that the controlled use of vegetation is likely to give more permanent results in the conservation of water than any other method. Like all opinions it must change if confronted by opposing facts and the only way to get these facts is by scientific experiment. There is no doubt that we must learn to use the rain with efficiency in these waste areas. Hitherto many farmers have selected their crops without due regard to the water economy. This neglect has not been of a serious nature in the humid temperate zones but it is of supreme importance in the dry, hot lands of the world.

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# CONSERVATION OF WATER FOR STORAGE UNDERGROUND

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Conservation of water means the diversion of rain falling on the land to the economic use of man. Storage underground implies that such storage becomes of use to man by maintaining the dry weather flow of springs and rivers, or by rendering water available for pumping from wells.

Throughout these notes it is presumed that the water table, i.e. the top of the saturated zone forming the underground reservoir, is at some depth below the surface. Where this depth is less than about ten feet, the roots of vegetation can draw water directly from the water table, resulting in greatly increased use of water in transpiration: These conditions occur only in limited areas in Kenya.

Works of water conservation may be classed as follows:—

(1) Impounding of flood waters in reservoirs by construction of dams across river valleys. This is referred to in the next section.

(2) Impounding of flood waters before they reach the river bed by construction of earthworks. This method is mainly used in connexion with soil conservation on cultivated lands.

(3) The spreading of flood waters over suitable land areas to replenish underground reservoirs. This method, though highly successful where favourable conditions exist, does not find general application.

(4) Increasing the amount of water entering the soil and reaching an underground reservoir by controlling the amount of water discharged into the atmosphere, i.e. by manipulating the vegetation. The method is still largely in the experimental stage but it is now recognized as of profound importance, and a discussion of the principles upon which it is based is the object of these notes.

## Conservation of Flood Waters by Construction of Dams

The designer of works for impounding flood waters is called upon to predict the incidence of rainfall during the life of the proposed works; this he can only do by a careful examination of past records. The spillway has to pass safely the highest probable flood, while the storage capacity must provide the required supply throughout the probable longest drought period, allowance being made for evaporation losses. In East Africa the hazard in constructing dams is much greater than in temperate climates due to the greater variability of the rainfall, and high evaporation, while the period of past rainfall records is too short.

Taking Naivasha as an example, rainfall records began at the Railway Station in 1904. In 1907 and 1908 the rainfall was 51.8 and 55.6 inches respectively, while in 1910 it was only 10.4 inches. From these records it is inferred that floods in 1908 were very high, demanding large spillways, while in 1910 runoff was negligible, requiring a minimum of two years supply as storage, including about 12 feet depth of water to allow for evaporation losses. Further analysis of records shows that for the first decade (1904–13) the average annual rainfall was 32.3 inches, whereas for the last decade (1935–44) this average was only 21.3 inches, and that this decline has been fairly steady. This indicates that the period of records is not long enough to enable future rainfall to be predicted; if any major work of surface water conservation were contemplated the designer can only assume that the decline in rainfall will continue.

The case of Naivasha is not exceptional or extreme in this Colony, while similar conditions occur in many countries, and have resulted in the failure of numerous dams and reservoirs.

## Underground Reservoirs

The difficulty and cost of storing flood waters where rainfall is erratic and evaporation high have resulted in increasing attention being given to the use of underground waters; but in some countries where such supplies have been highly developed or where dry weather flow of rivers has been decreasing, concern at the depletion of available supplies has led to a detailed study of underground reservoirs, and of the factors controlling their replenishment. It is not within the scope of these notes to discuss ground water reservoirs in detail, but mention must be made of some of their

characteristics. They are not subject to evaporation losses; movement of water through them is slow, often only a few feet per day, and hence the stored water is released slowly at the outlets; there is a limit to the rate at which water should be drawn from them, for the rate of depletion must not exceed the rate of replenishment, or the supply will gradually become exhausted.

In any particular area, for given rainfall conditions, the amount of rainfall penetrating to the water table depends largely on the type and density of the vegetative cover, the infiltration rate of the soil surface and the percolation rate of the soils and rocks. It is only in recent years that the factors controlling replenishment have been fully investigated, and methods devised for their quantitative determination.

### Disposal of Rain Falling on a Catchment Area

Rainfall may be disposed of in the following ways:—

(1) Interception by vegetation.
(2) Evaporation from the ground surface.
(3) Transpiration by vegetation, including water used in building plant tissue.
(4) Percolation to the ground water reservoir.
(5) Surface run-off.

In the following paragraphs values are given for some of the above factors, obtained from published accounts of experiments in various countries; but great caution is required in applying these values to other areas for they vary widely with climate and geology.

*Interception.*—Rainfall is measured in a gauge which is usually one foot above ground level, on a site clear of obstructions such as buildings and trees. This amount of rain does not all reach the soil unless it is bare; where there is a vegetative cover, some of the rain is held on the leaves, twigs and stems of the vegetation, and is subsequently evaporated. This loss of rain which does not reach the soil is known as interception, and varies particularly according to the density of the vegetative cover and with the frequency of showers or storms. Early experiments in Austria on 60 year old spruce stands showed that 63 per cent of the rain falling as light showers, and 39 per cent of the rain in heavy showers, was intercepted. Experiments in U.S.A. in recent years record from 15 per cent to 43 per cent of rainfall being intercepted by forests of various types, where undergrowth was sparse. In tropical forest with dense undergrowth, as occurs in some parts of Kenya, and where rain falls on about 200 days in the year, as in the Mau Forest, interception possibly exceeds 50 per cent of the total rainfall. No figures are available for interception by grasses, but it must be considerably lower than that by forests.

*Infiltration and Percolation.*—Rain reaching the soil surface may either be absorbed into the soil, or run over the surface into stream beds and depressions. Absorption, or rate of intake, depends on rate of infiltration of the soil surface and the percolation rate of the soils and rocks below. These two properties, one of the soil surface and the other of the soil profile, are quite distinct, but in general it is not easy to differentiate between the two. Infiltration rates are usually high in forest and grasslands, where the upper soil layer tends to have a granular structure, with large pore space, percolation rates are dependent mainly on the texture of the soil, but where roots of vegetation exist such rates tend to be higher.

Experiments on grass-covered plots with rain artificially applied as fast as it could be absorbed showed that in heavy clay loam on clay only 0.96 inch of water was absorbed in the first hour and 3.91 inches in 24 hours, whereas in brown silt loam (granular) the corresponding values were 5.36 inches and 48 inches. Experiments in New Mexico with various types of cover showed mean rates of intake of 1.55, 1.24 and 0.71 inches per hour respectively for grass, woodland and desert scrub covers. Experiments in California in connexion with spreading floodwaters for storage underground showed intake rates up to nine feet depth per day in coarse textured soils. In soil and water conservation experiments at Clarendon, Iowa, U.S.A., it was concluded after four years study that the rate of intake of different soils may vary so widely as to overshadow in magnitude all other control measures commonly used for reducing surface run-off. The rate of intake at any place is usually much higher when rain begins to fall on dry soil, but decreases to a fairly steady value after a limited period of rainfall.

*Surface Run-off.*—Whenever the rate of rainfall exceeds the intake rate of the soil surface run-off occurs into stream channels and depressions; in the latter case the water has a further opportunity of entering the soil, though some is lost by evaporation. The measurement of surface run-off is the item in the disposal of rainfall which in the past has received most

study. Many experiments have been made to ascertain the relative run-off from forests, grass, and bare or cultivated land; from forests it is usually less than 10 per cent, and frequently only about 2 per cent of the rainfall; from grassland the percentages are usually higher, but in both cases the amount of surface run-off is only a small percentage of the total rainfall, even where ground slopes are comparatively steep. Run-off from bare lands varies widely with slopes and with the texture of the soils and rocks.

*Evaporation from Soil Surface.*—Immediately the soil surface becomes wet it is subject to loss of water by evaporation, but experiments have established that this loss only occurs through a depth of about eight inches; over long periods there may be small losses from greater depths, but for practical purposes these are negligible. The amount of this loss varies with temperature, humidity, wind velocity, and with the frequency of rain showers. At Rothamsted, with an annual rainfall of 29 inches on about 200 days, evaporation from bare tilled soil has been found to be just over 15 inches per year, while in some parts of South Africa it has been estimated that all showers of half an inch or less on bare soil are returned to the atmosphere. Evaporation from soil covered by vegetation cannot readily be determined, but is obviously much less than that from bare soil; it is usually included in the total loss of rainfall due to vegetation.

*Transpiration.*—Transpiration is the process by which water, drawn by roots from the soil reservoir, escapes as vapour from the living plant through the leaves; water used in building plant tissue is also included in measurements of transpiration losses. Many experiments have been made to determine transpiration amounts by growing plants in pots, or recording loss of moisture by twigs, etc., but the results of these cannot be applied to vegetation growing under natural conditions. There are few experimental results available, but two cases from the U.S.A. are as follows: A hardwood forest with abundant scrub and minor vegetation, in a temperate humid climate having a rainfall of 70 inches distributed throughout the year, showed 15.4 inches depth of water transpired in seven months; while transpiration by riparian vegetation consisting of trees and herbaceous growth during six months of the summer was 45 inches depth of water, but in this case the vegetation had access to a constant supply of water. There are also many records of eucalyptus trees being planted to dry out swampy areas and lower the water table.

The measurement of transpiration alone presents considerable difficulty, and this water loss is usually included in measurements of the total loss due to a vegetative cover.

### Consumptive Use of Water by Vegetation

The above expression is used to include all water returned to the atmosphere from land covered by vegetation, and includes interception, transpiration and evaporation from the soil surface; it is usually expressed as inches depth of water. Various methods have been devised for measuring consumptive use, but the one most generally used is that which involves determination of changes in the moisture content of the soil reservoir. The amount of moisture in the soil reservoir can be found in various ways, generally from soil samples taken at various depths and suitable intervals of time. Consumptive use disposes of a very large proportion of rainfall; this proportion is generally over 75 per cent, and may reach 100 per cent. For the U.S.A., the following figures have been given as a general estimate of the yearly water losses, in inches, due to various types of cover: Short grass 10 to 20, tall grass 20 to 30, pines 20 to 40, Pacific Douglas fir 25 to 60. In the north temperate zone of the U.S.A., it has been estimated that the most mesophytic conifers require yearly 25 inches of rainfall, and hardwoods 30 inches. In South Africa, experiments in the veld showed that between 1934 and 1936 no water percolated to four feet depth, the rainfall being all used by vegetation, even though 25.7 inches fell during one period of six months. In tropical forests, with heavy tree canopy and dense undergrowth, high temperatures and long hours of sunshine, consumptive use is probably much higher than in forests in temperate climates.

In several countries the fall of the ground water table has been causing great anxiety, and methods of increasing the replenishment of ground water are under consideration. One such method consists in changing the type of vegetative cover to one having a low consumptive use, and experiments are in progress to determine the water requirements of various vegetative types; the results, however, do not admit of general application. In Kenya, many areas of high rainfall yield little water either as surface or ground water run-off; the programme for conserving the water resources of

the Colony should include measures that aim at a greater proportion of the rainfall reaching useful ground water reservoirs.

### Soil Moisture and the Soil Reservoir

Water used in transpiration is drawn from water stored in the soil, and it is now necessary to consider the nature and extent of this storage.

After heavy rain, water moves downward through the larger pores of the soil under the force of gravity and is known as gravitational water. After gravitational water has drained away, a soil is said to be at its field capacity. The amount of water so held by a soil is expressed as a percentage of the weight or volume of the soil. The field capacity is usually very close to the moisture equivalent of a soil, which is the water content of a soil which has been subjected to a centrifugal force of 1,000 times gravity. Permanent wilting percentage is the moisture content of a soil at the time the leaves of plants growing in that soil first become permanently wilted, and represents the stage at which absorption of water by roots is too slow to replace water lost by transpiration. Available water is that amount of water in a soil in the range between field capacity and permanent wilting coefficient, and represents the water available to the vegetation growing in that soil. Hygroscopic water is the water in the soil that is in equilibrium with atmospheric water vapour. Soil with this very limited amount of water is usually only found at or close to the soil surface when evaporation is finished. The water table is the top surface of the underground reservoir of water, and below this surface the soil or rock is saturated. Water draining through the soil to the water table provides an increment to the ground water reservoir, and it is this which constitutes the replenishment of such reservoir. Above the water table the soil always contains a certain amount of water, but the amount may vary from its maximum when the whole soil profile is at the field capacity for that soil, to a minimum when the top few inches retain only hygroscopic water, and below this the water content has been reduced to the permanent wilting percentage by roots of vegetation.

The amount of water used by vegetation plus that lost by surface evaporation is also the amount of water necessary to restore the soil to its field capacity, and it is only after this has been done that further water can percolate to the water table. Thus the soil reservoir must be filled before the ground water reservoir can receive any replenishment, and it is usually only as a result of prolonged rainfall that this can occur.

The depth of the root zone of the vegetation represents the depth of the soil reservoir suffering depletion, and requiring replenishment. Experiments in U.S.A. showed that at the end of a dry season, soil on which alfalfa was growing had been depleted of all its available moisture to a depth of 25 feet, while on high ground under trees, the soil moisture had been reduced to wilting percentage to a depth of 14 feet; depletion of soil moisture under grass sod had occurred to a depth of seven feet, but in a lesser degree.

### Amount of Water in the Soil Reservoir

The necessity of determining the water requirements of vegetation, both in connexion with ground water supplies and irrigation, has led to the study of the amount of water that can be held against gravity by various types of soils, and of the available water, and the following table is representative of results:—

| | Fine sand | Sandy loam | Silt loam | Loam | Clay |
|---|---|---|---|---|---|
| Moisture equivalent (percentage) | 3·2 | 9·5 | 16·1 | 21·7 | 28·4 |
| Permanent wilting (percentage) .. | 1·0 | 2·9 | 7·5 | 10·3 | 13·4 |
| Available water (percentage) .. | 2·2 | 6·6 | 8·6 | 11·4 | 15·0 |
| Inches depth of water per foot depth of soil— | | | | | |
| Moisture equivalent .. | 0·6 | 1·7 | 2·5 | 3·3 | 4·5 |
| Available water | 0·4 | 0·9 | 1·3 | 1·7 | 2·3 |

Adapted from "Evaporation from soils and transpiration" by F. J. Veihmeyer. *Transactions of the American Geophysical Union*, 1938, Part II.

The percentages are in relation to the oven dry weight of soil.

Attention is drawn to the available water, and it is noted that clay holds a very much larger quantity than sand. Therefore sandy soils are much more likely to provide increments to ground water than clay, for the amount of water required to restore the soil to field capacity is very much less. The depth of the root zone is now seen to be a very important factor; shallow rooted vegetation has much less available water to draw upon than deeper rooted types in similar soils, and in a long dry season will die and cease to use soil moisture sooner than the latter.

To indicate the amount of rainfall required to replenish a soil reservoir, a hypothetical case may be taken of an area covered with forest and undergrowth. At the end of a dry season the roots will have almost exhausted available water to a depth of about ten feet in silty loam soil. The soil reservoir then requires over ten inches depth of water to restore moisture content to its field capacity; the rainfall required to supply this amount of water in the soil would be about 18 inches, allowing 40 per cent interception loss by the forest canopy and undergrowth. But during the period that this rain might be expected to fall, transpiration and soil evaporation continue, while some surface run-off may be expected, so that the actual rainfall required to restore the soil to field capacity might vary from 25 to 35 inches, depending on the frequency, duration and intensity of rainfall; this represents the amount of rainfall necessary before any water can be expected to penetrate to the ground water reservoir, and this rain must fall before the commencement of the next dry season.

### The Improvement of Ground Water Supplies

An investigation having as its object proposals for the improvement of ground water supplies in any area requires a study of the geology and hydrology of the area. This begins by determining the recharge area of the ground water reservoir the supplies of which it is proposed to improve; this may comprise the whole or only some portion of the surface catchment area, or may be wholly or partially outside it. In some areas investigation may indicate that no improvement in supplies is possible for various reasons, such as the water table being too deep for economic development of supplies, or where impervious and unfractured rock is overlain by shallow soil, or where the ground water passes out of the area to discharge into areas where existing supplies are abundant. A soil survey is required in order to eliminate from further consideration any area where the soil contains so much clay and to such depth that the percolation through it is likely to be negligible under any conditions of land cover. Then follows an experimental determination of the percolation rate through the soil profile at various points in the area, and the field capacity of the soils. Past rainfall records must then be examined, to determine the intensity and duration of the major storms, i.e. those most likely to contribute replenishment to ground water; also the number of days on which light showers are experienced, i.e. that portion of the rainfall which even with moderate vegetative cover, will not reach the soil, or be at once lost by evaporation from the soil. The results of this examination will indicate whether the area can support a vegetative cover, and still provide increments to ground water. Finally, the consumptive use of various types of vegetation suitable to the area must be determined; if values of such water losses have already been obtained in similar areas and conditions elsewhere then such values can be applied to the area under consideration.

The results of the investigations outlined above should enable decisions to be made regarding the treatment which the land surface should receive to ensure maximum ground water supplies without danger of soil erosion; the areas can be defined where forest may be grown without detriment to the water supplies, and where grass may be advantageous; and in exceptional cases may indicate that some areas should be kept bare of any but the lightest cover. A similar investigation in any area in which afforestation is proposed should supply the answer to that very vexed question—what will be the influence of such afforestation on water supplies? In fact, knowledge is already so far advanced that it may be stated that no steps should be taken to afforest any catchment area forming a recharge area to a useful ground water reservoir without first investigating the effect of afforestation on the water supply.

### Evaporation and Precipitation

The effect on precipitation of evaporation from inland water surfaces and of transpiration of vegetation has received a great deal of attention in the past, but, as in the case of the problem of forests and water supplies adequate evidence has until recently been lacking to form any definite conclusion. A few years ago, however, the United States Weather Bureau inaugurated a programme of comprehensive upper air research, and the data being obtained have served to point out certain deficiencies and inconsistencies in older conclusions concerning atmospheric and hydrologic relations. B. Holzman, Assistant Climatologist of the U.S. Soil Conservation Service, has discussed the subject in the light of the more recent knowledge and the following notes are abstracted from his writings. Roughly one-fourth of the total precipitation on continents has been recognized as the quantity returned to the seas by run-off, and three-fourths as the quantity returned to the atmosphere by evaporation. (It is to be noted, however, that in Africa the portion of the precipitation that returns to the sea is very much less; thus in

South Africa this portion is estimated at only 6 per cent, while in East Africa it is probably even less.) It has been argued by many writers that this large amount of evaporation from the continents was mainly reprecipitated on the continents. In fact measures to increase evaporation from continental areas were advanced as means of increasing local precipitation. A study of depth of water in the atmosphere reveals that there is no immediate relation between precipitation and the total atmospheric moisture content. The average moisture concentration in the lower levels of the atmosphere over desert regions may be greater than in provinces classified as rain forest. The process of precipitating atmospheric moisture is known to depend on several variables, and no simple procedure involving solely an increase in atmospheric moisture can be expected to increase local or other rainfall. Various soil conservation measures aid in returning excess rainfall to the oceans by increasing the absolute amount of evaporation into continental air masses. Contrary to theories widely held, the major part of the moisture absorbed by these air masses is not reprecipitated on the land, but is carried back to the oceans.

### Grass as a Cover to a Catchment Area

The advantages of grass as compared with forest for better replenishment of ground water reservoirs are now being advocated in some countries, and experiments to establish these advantages are in progress; it has already been proved that a good grass cover is a most effective means of preventing soil erosion, and controlling surface run-off. The great advantage of grass lies in its low consumptive use as compared with a forest having undergrowth. In U.S.A. elaborate experiments have been made with wheat grass, which prevented soil erosion on a 40 per cent slope; this grass grows to about nine inches in height, and its root system is a dense fibrous mass for a depth of about three feet. Such grass has low interception loss, and transpiration is limited, since it can only deplete soil moisture to a depth of about three feet. The dense root system, it is contended, not only binds the soil together but promotes high percolation rates. This is in agreement with other writers whose experiments have indicated that the soil structure under grass is favourable to good infiltration while the root system aids percolation. It has also been established that grass uses much less water if it is kept clipped; thus water loss from grazed grasslands are lower than from ungrazed, but grazing requires to be controlled to avoid too much trampling, which results in increased surface run-off and possibly erosion of soil, due to lowering of infiltration rate.

### Catchment Areas Bare of Vegetation

Where the soil is clay or loam, the granular structure of the soil surface associated with vegetative cover is lacking, or broken down by the rain, the impact of which also tends to seal up the pores, thus reducing infiltration rates and increasing surface run-off, which becomes turbid by erosion and deposits fine particles in depressions, rendering the surface still more impervious.

Where the soil is sandy, particularly if the sand is coarse, the rate of intake is high, and no run-off or erosion occurs on moderate slopes unless rainfall intensity reaches very high values. The loss of water is therefore confined to evaporation from the soil surface; the field capacity of sand being low, and evaporation only being effective for a few inches below the surface, the amount of water returned to the atmosphere after each shower of rain is very small. If the rainfall occurs mainly as storms of long duration on a limited number of days, total yearly evaporation loss will be small, and there being no interception or transpiration by vegetation, and low run-off, the replenishment of ground water will represent a considerable proportion of the rainfall.

Particular application of the above general principles may be found in the coastal area of Kenya north of Mombasa; this area, up to four or five miles inland consists largely of sandy soil overlying sand, coral or gravel, with a high intake rate. The annual rainfall is between 40 and 50 inches on about 100 rain days and there is very little surface run-off, yet very frequently the ground water is brackish or saline, indicating the probability of poor replenishment of the fresh water lying on top of the saline water. It is to be expected that the dense bush covering large areas, by interception and transpiration, would account for a large proportion of the rainfall. If this bush were cleared the water loss would be reduced to soil surface evaporation, which would probably not appreciably exceed the amount now being lost by interception and soil evaporation. Therefore, an amount about equal to the present transpiration would percolate to the ground water table. In a few years this additional yearly increment to the ground water should result in a higher water table, and water supplies would consequently improve in quantity and quality.

# MURRAM BLOCKS

By J. F. Low, Agricultural Department, Uganda

A building material for the construction of semi-permanent to permanent type buildings has been the subject of trial at Serere Experimental Station, and the results have shown that a good class building can be erected by semi-skilled labour at very low cost. Three qualities of blocks have been made, all of which are satisfactory according to the standard of work required and the amount of money available.

### Ordinary Murram Blocks

The materials required are:—

*Loose Murram*, decomposed shale, rock, etc. Undoubtedly many materials will make blocks, but the best in our experience are made from murram.

*Cattle Manure.*—This is used as a binding agent and is mixed with the murram in a fluid state.

*Rammers.*—Iron rammers are best, but in default of iron, wooden rammers can be used. They should be about twelve inches long, the ramming end being bluntly wedge-shaped. The exact design of the rammer is not of great importance, and it depends on what old iron is available but too flat an end should be avoided, otherwise the mixture will not be rammed properly.

*Box Moulds.*—A minimum of three mounds is required, made from 1¼ in. timber. The inside measurements are 12 in. long by 9 in. wide by 8 in. deep. The outside measurements are 20½ in. long by 15½ in. wide, with the same depth. This allows for the cutting out of the lugs of the end pieces. Figures 1, 2 and 3 make clear the details of construction. Fig. 4 shows the bottom board which is simply a board on which the box rests while the ramming process takes place, and is also used for carrying the block away. It is the same length as the box, but 13½ in. wide. Two struts nailed to the underside keep it slightly off the ground and aid stability.

*Water.*—This is required to make the manure fluid. The proportion is one gallon of water to two good handfulls of manure.

### Organization of Labour

A unit of five men constitutes a gang. Three men are allocated to the box moulds, each man being responsible for ramming one mould. The fourth man brings water, prepares the fluid manure, mixes it with the murram and feeds it to the rammers. The fifth man digs the murram and brings it to the mixer.

The five men work together as a team; they come to work together, and leave together when the day's task is finished. It is to each individual's advantage, therefore, to lend a hand to the others with anything that holds up the work; thus they all help to get the first heap of murram mixed and then carry on with their specified jobs.

### Technique

The mixing of the manure and murram is carried out in a small basin-shaped hole about one foot deep by two feet diameter dug in the ground, and manure is rubbed round the inside to make the hole waterproof. No special preparation of the murram is necessary, it is just used as it comes from the ground, throwing out any large stones over about two inches diameter. The fluid manure should be mixed with the murram in such proportion as to result in a semi-dry consistency; if it is too wet it cannot be rammed properly. The mixture is put in the moulds, about a four-inch layer at a time, and lightly, but firmly rammed; great force is unnecessary. One hand should be laid on the box during the ramming of the first layer to prevent "creeping". When the material has been rammed to the top of the box, it should be tamped down to make a neat flat finish, a round-headed road rammer is useful for this purpose, or a flat piece of fairly heavy wood can be used. The wooden wedges are then immediately knocked out, and the sides and ends of the box are taken off, leaving the block on the bottom board. The block is carried off on the board to the drying area, tipped gently, placing one hand on the face of the block, and letting the block slide gently off the board to rest on its side. A long grass shed, similar to that used in brick making, should be built to protect the blocks from heavy rain till they have dried out. Sand or ashes should be rubbed over the internal surfaces of the box after each block is taken out, to prevent sticking.

### Cost

The task for the team of five men is 90 blocks per day. At Serere the cost of labour is 50 cents per day, making the cost per block 2.8 cents. As each block is the equivalent of about five standard size bricks, the cost of the substitute for 1,000 bricks works out at

FIG. 1

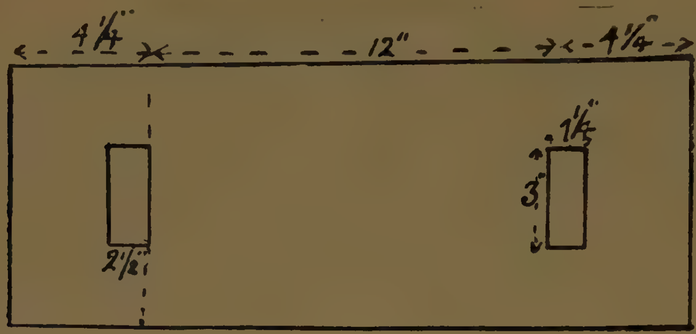



FIG. 2

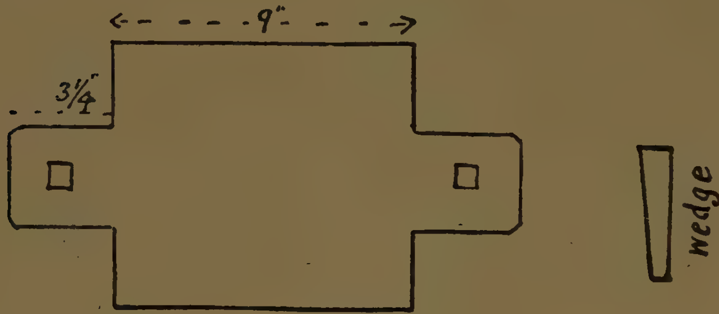



FIG. 3

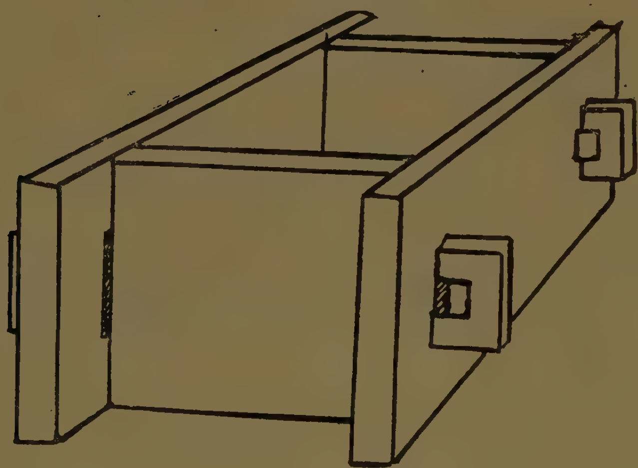
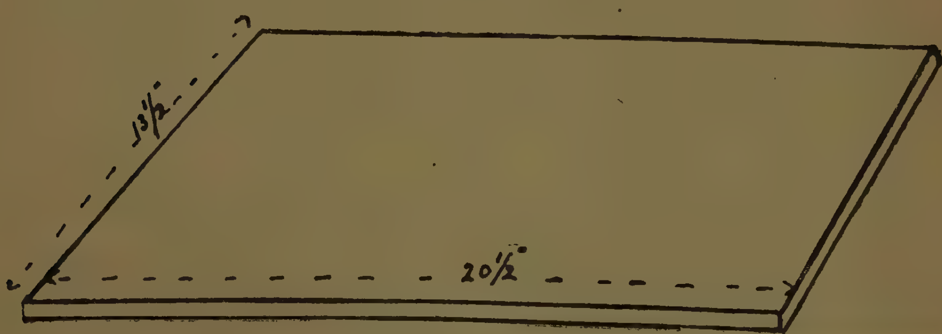


FIG. 4



Sh. 5/60, with the added advantage that the blocks can often be made where the building is required, thus eliminating transport costs.

### MURRAM BLOCKS WITH BUILDING LIME

The use of building lime is a distinct improvement and results in a much harder block, but of course the cost of the lime must be taken into account. The procedure is the same except that water is used instead of the fluid manure; the lime and murram must be mixed in a wetter condition than with ordinary blocks to allow the lime to permeate through the murram, and the mixture must then be turned over to allow it to dry out sufficiently to be in proper condition for ramming; this, however occurs in a very short time.

For wall blocks the proportion of murram to lime can be 10 to 1, but for foundation blocks this should be reduced to 6 to 1. The 6 to 1 mixture stood up to 13 inches of rain in one month without any visible effect. The 10 to 1 block also stands up well to ordinary storms, uncovered.

### MURRAM BLOCKS WITH CEMENT

The proportion of murram to cement is 10 to 1, and the procedure is exactly the same as for the blocks made with building lime. A very hard block is produced that will stand up to any weather; the cost is, however, about double that of the lime block.

### NOTES

The block made with manure is the cheapest, but is unsuitable for foundations, and buildings made with this must have either lime or cement blocks for the foundations up to plinth level, and be protected from rain until the roof is on.

The blocks can be fully exposed to the sun, they do not crack.

The size of the moulds can be varied to suit individual requirements, but size has to be considered in relation to the efficiency of builders when handling heavier blocks.

The porters should not be allowed to hammer in the wedges when assembling the box; a slight tap is sufficient.

Strapping nailed over the wearing surfaces strengthens and prolongs the life of the mould. Strapping is also necessary round the lugs, to prevent splitting by careless porters.

The composition of the team is given as a guide, but will vary according to conditions.

## PROPRIETARY INSECTICIDES AND FUNGICIDES

The Ministry of Agriculture and Fisheries in Great Britain has recently started a voluntary scheme for the official approval of insecticides and fungicides sold under brand names. The objects of the scheme are (1) to enable those concerned with giving professional advice on the control of plant pests and diseases to recommend by name, on reasonably sure foundations, an appropriate range of products, (2) that the consumer should see at a glance that the product he intends to purchase is a suitable one for his purpose. There are two classes of products for which official approval can be obtained; the first includes those guaranteed by their makers to conform to an agreed official specification; the second includes those for which no official specification is at present available, but of which the chief active ingredients are declared, so that the Advisory Committee of the Ministry of Agriculture can assess their value. No product the composition of which the manufacturer desires to keep secret can be accepted for approval under the scheme.

Approved products bear the official mark of approval of the Ministry of Agriculture. The scheme is restricted to insecticides and fungicides marketed in Great Britain. Whether some similar scheme would be practicable and valuable in the Colonial Empire is worthy of consideration.

T.W.K.

## GOATS *versus* SHEEP

Usually goats are blamed more than sheep for the damage done to range, but in Somaliland the sheep are more damaging than the goats. For, when grazing is short the sheep will continue to eat grass, and the roots may even be dug up for or by them; and, when the new grass first appears they form a wide line abreast, and like some huge mowing machine devour all new grass in their path. The goats do at least scatter to browse and they do spare the grass roots.

Annual Report for 1938 of the Veterinary and Agricultural Officer, British Somaliland.

# CAMPHOR PRODUCTION IN EAST AFRICA FROM CINNAMONUM CAMPHORA

By A. G. G. Hill, B.A., Agr.B., B.Sc., Director, East African Agricultural Research Institute

(*Received for publication on 27th September*, 1945)

When asked in 1941 to design, erect and operate a factory for the manufacture of camphor, an essential war-time commodity urgently needed in Britain to replace Japanese supplies, little information could be found on the subject beyond that contained in the references given at the end of this article, none of which dealt with the design, or running, of a full sized factory producing 1,500 to 2,000 lb. of solid camphor per week, which was our aim. For this reason it is thought that the following description of the design and working of the war-time camphor factory erected at Lushoto, Tanganyika, by this Institute in 1941–42 may be of value to those interested in the possibility of developing a camphor industry in those parts of the world where *Cinnamonum camphora*, the Chinese or Japanese camphor tree, will thrive.

The first step before considering the erection of a factory was to confirm that the trees of the only existing camphor plantations in East Africa, situated in the East and West Usambara Mountains, Tanganyika, contained camphor in worthwhile quantities. Laboratory tests had shown that wood and leaf samples from these plantations gave satisfactory yields of both camphor and camphor oil, but it was decided to corroborate this by conducting distillations on a larger scale. A pilot plant, with a still capacity of 73 cu. ft. was therefore designed and constructed at Amani to confirm the laboratory results and to obtain further data on which to base the design for a full sized factory. The yields obtained from this pilot plant were reassuring and amounted to 1.2 to 1.5 per cent of solid camphor plus 0.3 per cent of camphor oil from the steam distillation of leaves, and 0.6 per cent solid camphor plus 0.15 per cent camphor oil from the distillation of the wood. The information provided by this pilot plant proved exceedingly valuable in designing the full-sized factory subsequently erected. Only in one respect were the pilot plant figures seriously misleading and that was in the time taken for distillation. This was mainly due to the fact that the camphor wood chips distilled in the pilot plant were cut on a planing machine; whereas those used at the factory were cut on special chipping machines producing larger sized chips.

Inquiries made in East Africa and abroad showed that special plant and machinery for manufacturing camphor on a factory scale could not be bought and apparently did not exist. It was therefore necessary to design the necessary chippers, stills and condensers and arrange to have them constructed locally. In this we were fortunate in having the advice and help of the Chief Mechanical Engineer, Tanganyika Railways, who undertook to have chipping machines and stills constructed to our design and to supply boilers, motive power and shafting for the factory.

The following is a brief description of the plant and machinery used in the factory:—

*Chippers.*—Having failed to find a suitable design for these machines,* an experimental machine, on the principle of a chaff cutter, was designed. This machine, although very heavily built, was found to be too small and light for the heavy work required of it. Four chippers of modified design were subsequently built for us by the Tanganyika Railways each of which was capable of chipping approximately 60 cu. ft. of packed camphor wood per hour when driven by 7½ h.p. and running at 1,440 revolutions per minute.

*Stills.*—Six cylindrical stills were constructed each 6 ft. in diameter by approximately 6 ft. high. (*See* illustrations Nos. 1 and 2.) Each of these steel stills had an effective capacity of 160 cu. ft., equivalent to a charge of 1,600 lb. of camphor leaves and twigs or 2,400 lb. of chips. Each still was fitted with a water-sealed manhole on top and a vertical screw-fastening manhole at the bottom. The steam inlet was through a 1 in. steam cock and a two-way valve at the bottom and the vapour outlet through a 3 in. pipe in the top. The outside vertical surfaces of the stills were lagged with dried banana leaves to minimize heat losses. A seventh still was added later.

*Condensers.*—After numerous experiments, seven box condensers of the type shown in

* The machine known in the U.S.A. as a Sawmill Hog would probably have been the most suitable, had it been obtainable.

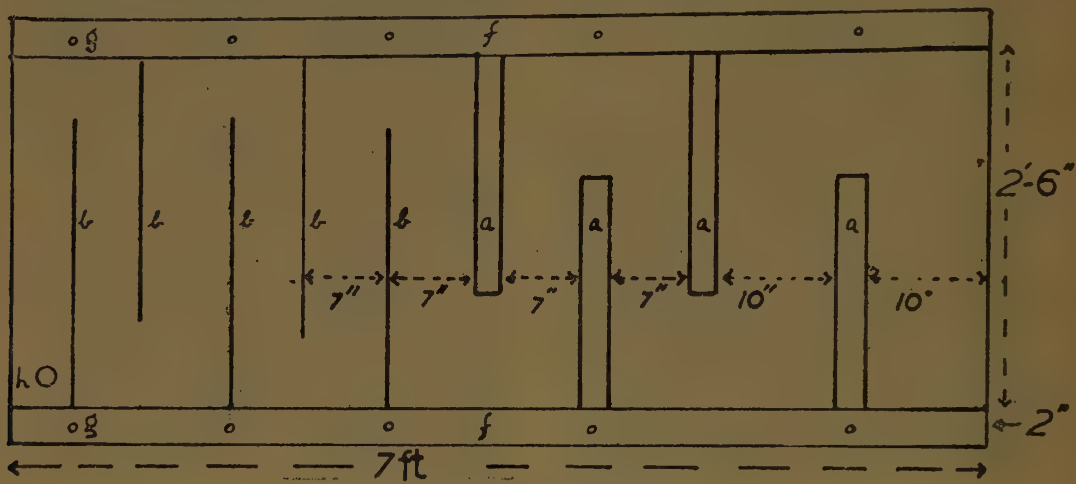
1—The Factory

2—Discharging a still into low-loading trolley

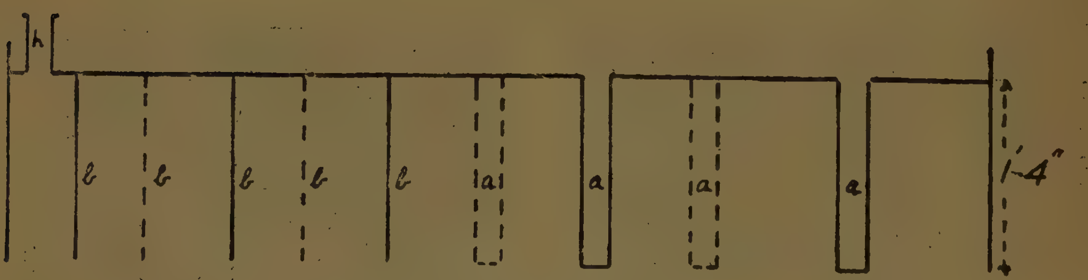
3—The condensers

4—Condenser (underside) and its box

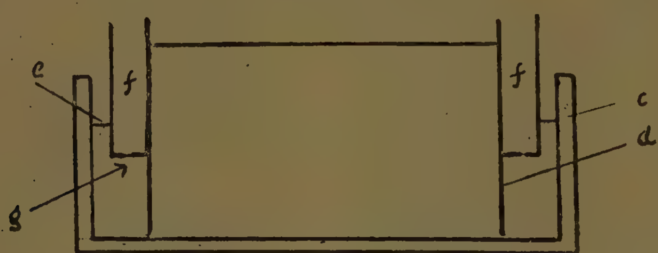
illustration No. 4 and Fig. I were devised and made in the Amani workshop. Each of these consisted of an inner galvanized iron box open at the bottom and divided by vertical baffles into a series of communicating compartments in the form of a maze. This inner box was placed in a shallower, but larger, wooden box open at the top and half filled with water to act as a seal between the inner and outer boxes. When in operation cold water flowed over the top of the inner galvanized iron box into perforated saddle-tanks at the sides and so into the outer wooden box whence it escaped through a notch cut in the side. A steam-driven pump supplied cooling water through a 3 in. pipe from a nearby stream to a wooden trough




Sectional Plan of Inner Box.




Sectional Elevation of Inner Box.




Cross Section of Inner and Outer Boxes.

*a*. Water-cooled baffles.
*b*. Plain baffles.
*c*. Outer box, wood.
*d*. Inner box, galvanized iron.
*e*. Water-level in outer box.
*f*. Saddle-tanks.
*g*. Perforations in saddle-tanks.
*h*. Outlet for vapour.

FIG. I—CONDENSER

above the battery of condensers whence it was fed to the top of each through a short length of pipe, *see* illustration No. 3. Vapour from its own particular still entered the inner box of each condenser at one end and during the process of finding its way through the maze of baffles was condensed, leaving solid camphor on the top of the box and its baffles, or on the surface of the water within where it mixed with the condensed camphor oil. Four of the baffles were hollow and water cooled. The inlet pipe to the condenser from the still was secured by a flange held by four bolts which had to be unscrewed before removing the inner box on completing a distillation. This simple type of box condenser proved very effective, most of the products of distillation being condensed in the first four compartments.

*Motive Power*.—This was supplied by a twin-cylinder, 30 h.p. steam-engine working at 80 r.p.m. This engine was not capable of driving the four chipping machines at full efficiency, but no other was available.

*Boilers for Stills*.—In the beginning steam was supplied by two wood-fired vertical boilers. Later a third boiler was added. These were found to be insufficient for supplying steam to seven stills, therefore, a large horizontal boiler of 150 h.p. capacity was installed, capable of supplying saturated steam to the stills and water pumps and superheated steam to the engine. The external fire box of this boiler was converted for burning spent camphor-wood chips from the stills, a conversion which resulted in a very considerable saving in fuel costs.

*Water Pumps*.—Two steam-driven pumps were used; one for the boiler and another for the box condensers.

*Power Grinder*.—This was in continuous operation sharpening knives for the chippers.

## Manufacturing Process

The process is a simple one, nevertheless it is worth recording here, since no similar description appears to be available in the literature of camphor production.

The main camphor plantation exploited was in Bushbuck Valley, Lushoto,* the trees being 30–35 years old, and well grown where they had been properly thinned. After felling, the trees were stripped of their leaves and twigs, which were packed in sacks, and the logs and branches cut into convenient lengths. Logs, branches and leaves were then transported in rail trolleys to the factory yard, where the logs and branches were split into billets about 4 ft. long and 4 in. square. These, with the leaves and twigs, were carried to the four chipping machines, each of which was tended by two men, one feeding the machine and the other passing billets to the feeder. The chips from the outlets of these machines were delivered into a central channel and from there were swept to a delivery platform situated above the row of seven stills, whence they were delivered to each still in turn through a manhole in the top of each. The loading and packing of each still occupied approximately 40 minutes. Saturated steam (optimum pressure 80–100 lb. per sq. in.)† was then introduced, entering each still through a series of holes punctured in pipes set radially below a loose perforated base-plate, or false bottom, fixed 4 in. above the true bottom of each still. This steam supply was controlled by an ordinary shut-off steam-cock coupled in line with a two-way plug-valve having two holes, one large and one small, bored in the plug at right angles to one another. This arrangement allowed of three settings; on or off by shut-off valve and high-flow or low-flow through the plug valve. During each distillation the high-flow valve was opened until the chips had been thoroughly heated after which the low-flow valve was used until the distillation was complete. A water seal was provided on top of each still to prevent the escape of vapour from around the edge of the weighted manhole cover, which was free to lift should the pressure in the still become excessive. After each steam distillation, which on the average took approximately seven hours (with extremes of five and nine hours), the spent chips‡ and leaves were discharged through a vertical manhole at the bottom of the still into a flat-topped rail-trolly below, capable of taking the whole charges.

The products of distillation were led from the top of each still through a 3 in. pipe to a box-condenser, described above. This type of condenser needed little attention beyond regu-

* Approximately 4,500 ft. a.s.l., average rainfall 42.4 in., mean max. temp. 73.3°F., mean min. 52.6°F.

† Less than 80 lb. caused unduly long distillation, higher than 100 lb. caused excessive heat in the condensers.

‡ In a series of experiments carried out by F. J. Nutman it was shown that a very useful type of fibre-board could be made from surplus spent chips not needed for fuel.

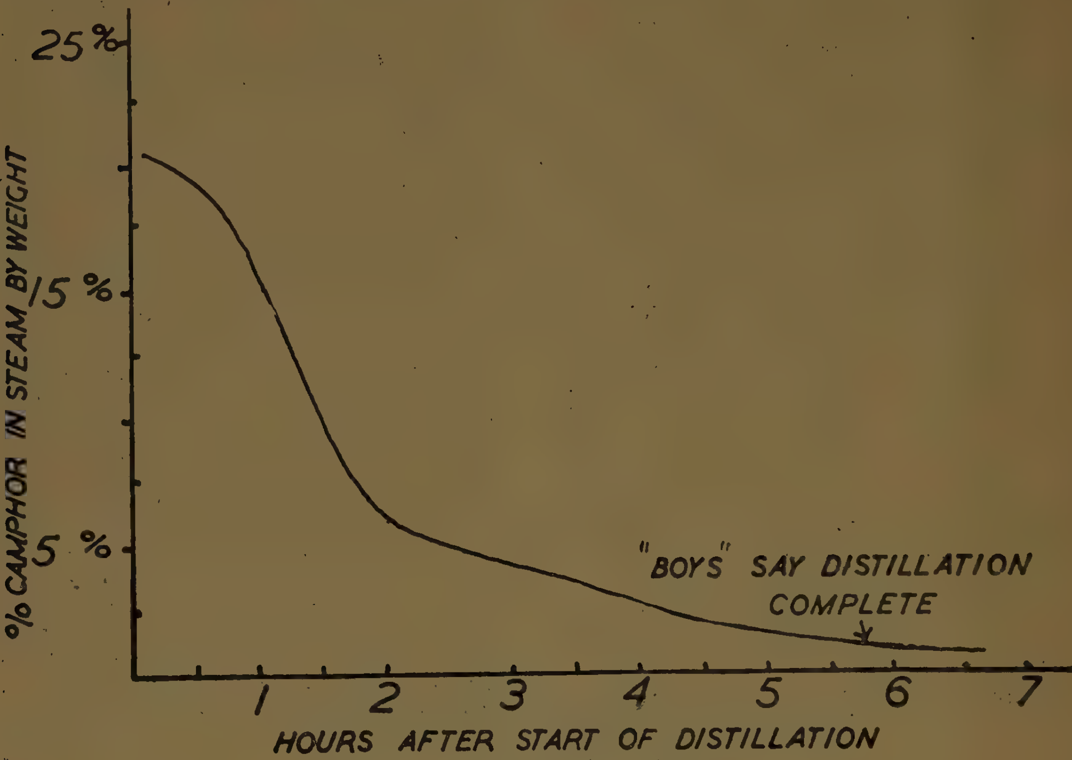



FIG. II—DISTILLATION CURVE

lating the water supply so as to obtain the maximum cooling effect and adjusting the rate of vapour flow to ensure that no uncondensed camphor was lost through the outlet of the condenser. If camphor crystals were found forming on the inside of the cylindical outlet from the condenser it was necessary to reduce the vapour supply by regulating the steam-cocks fitted at the bottom of each still. The end-point of distillation was determined by holding a small glass condenser in the hand over a hole tapped in the inlet pipe to the condenser for half a minute and then passing a plug of cotton-wool on a wire through the central glass tube. If no camphor crystals collected on the cotton-wool, distillation was taken as being complete. The glass condenser used was of the ordinary Liebig type, filled with cold water, the inlet and outlet for the water being plugged. A typical distillation curve, recorded by F. J. Nutman, is shown in Fig. II. This curve is interesting since it shows, (1) that the above method of determining the end-point of distillation can be successfully carried out by African workmen and (2) that the bulk of the yield was obtained in the first few hours of distillation. The yield of camphor oil, most of which came over in the first hour and a half, is not recorded in the graph.

On completing each distillation, the water and vapour supplies to the condenser was cut off, the vapour supply pipe disconnected, and the inner, or metal, part of the condenser lifted and inverted. The solid camphor deposited inside was then removed from the sides, top and baffles of the inner condenser with wooden scrapers. The solid camphor, mixed with camphor oil, which had formed on the surface of the water in the outer box, was removed with strainers, made from squares of brass mosquito-gauze stretched on wire frames, and transferred to a sausage-shaped cotton straining bag for the removal of any remaining oil. The camphor oil on the surface of the water was then skimmed off with metal scoops and transferred to a separator for the removal of the admixed water. This separator consisted of a galvanized-iron tank, approximately 4 ft. long, 6 in. wide, 3 ft. high at one end and 3 ft. 6 in. at the other, fitted with an inlet at the top and a glass gauge at the deep end to show the depth of water and supernatant oil inside after

separation. A tap was fitted at the bottom of the deep end to draw off the water and a second tap, 6 in. above the first, to draw off oil. Separation took place after the mixed oil and water had stood for about 12 hours. No attempt was made to recover solid camphor from the oil by freezing or distillation although laboratory trials had shown that by cooling to 7°C. 4 per cent of solid camphor was recoverable from the oil. By distillation of the oil at 195°–200°C. 11½ per cent of solid camphor was recovered in the laboratory, cf. Messrs. Whiffen's results on p. 154.

The performance of the factory over a period of 40 working weeks (2,878 distillations) during which time good raw material, wood and leaves, from well-grown trees was available for distillation is shown below:—

| | |
|---|---|
| Average weekly production .. | 1,730 lb. (crude)* |
| Average number of distillations per week .. .. .. | 72 |
| Average yield per distillation .. | 24·3 lb. (crude) |
| Average period for distillation .. | 7·3 hours† |
| Average yield from raw material— | |
| Crude solid .. .. .. | 0·57 per cent |
| Crude oil .. .. .. .. | 0·27 per cent |

*That is solid plus oil, with a small percentage of admixed water.

†Reduced to 5·9 hours after installing the larger boiler.

The crude solid camphor and crude camphor-oil were packed separately in 44-gal. steel oil-drums for export.

*Labour Requirements.*—The number of men normally required to keep the factory in full operation is shown below:—

(*a*) Felling trees and cutting to 8 ft. lengths: 10 men.

(*b*) Transport to splitting shed: 30 men.

(*c*) Splitting logs: 20 men.

(*d*) Carrying to chippers: 6 men.

(*e*) Feeding and attending chippers (working 1½ shifts): 18 men.

(*f*) Distillation. Two 8-hour shifts of 16 men: 32 men.

(*g*) Discharging stills and transporting refuse to dump: 14 men (two shifts of 7).

(*h*) Drivers, firemen, pumpmen, waterboys, fuel carriers: 21 men (three shifts of 7).

(*j*) Miscellaneous, e.g. clerical staff, headmen, mechanics, maize millers, butchers, ration clerks, cooks, charcoal burners, packers, etc.: 44 men.

Total 195 men.

These labour requirements could be cut very considerably by employing one Hog in place of four chipping machines, thus doing away with the need for cross-cutting and splitting the logs into short lengths while at the same time reducing transport and carrying charges.

The cost of casual labour in the Lushoto District when the factory opened was only 33 cents per day, without rations or housing. The labourers employed at these rates were, for the most part, unsatisfactory, mainly owing to absenteeism and low work output. It is interesting to record, therefore, that when wages were increased to about double by the issue of rations on the Government scale and the provision of housing on the factory site, absenteeism was reduced to a very low figure and work output per man increased considerably. A hot snack, or hot sweet tea, served during a shift was also found of great assistance in increasing production.

## Observations on Camphor Yields and Costs of Production

*Yield.*—There appears to be no information available on the formation or function of camphor in the tree. Great variation was found in the yield of camphor and camphor oil per distillation, depending on the type of material distilled and the weather at the time of felling the trees. It is unfortunate that pressure of work did not allow of an investigation into the influence of weather on yield. There were distinct indications that a seasonal variation occurred in the camphor content of the trees; thus, after prolonged periods of heavy rain and sunless days the percentage yield of crude camphor, even from mature trees, was depressed appreciably. The best yields were obtained during sunny weather a few weeks after the rains had ceased and before the forest floor had dried.

Yields per distillation varied between 9 and 48 lb. of crude camphor, the yield of solid to oil being in the ratio of 2:1. Raw material from prime trees of 35 years, 24 in. in diameter breast high, grown where they had ample space and light and cut in fair weather, could be expected to yield about 24 lb., or 1 per cent by weight, of crude camphor per distillation. Material from stunted and overcrowded trees of the same age, but 10 in. only in diameter, would yield 16 to 18 lb., or 0.66–0.75 per cent by weight, per distillation. The record yields of 40–48 lb. per distillation (=1.66–2 per cent

crude camphor) were obtained from the living butts of large trees which had been felled 15 months earlier. Leaves and twigs, mixed, gave comparatively low yields per distillation, i.e. 12 to 16 lb. (=0.75–1 per cent crude camphor) mainly because no more than 1,600 lb. could be packed into a still, compared with 2,400 lb. of chips.

Apart from variations in yield due to position and weather, there were distinct indications that the inherent qualities of individual trees were an important factor in determining yield. Thus, certain trees, cut in fair weather, gave outstandingly good yields whereas their neighbours, cut at the same time, gave low or only average yields and, in one case, no solid camphor whatever but only oil. Such observations suggest that the recording of individual tree yields, with a view to vegetative propagation from the best, would be a valuable line of inquiry.

Yields were also affected by delay in distillation, e.g. chips left in a heap for a day or more before distillation gave poor results.

The average yield of crude camphor (solid plus oil) per acre, calculated on the area felled during the 22 months that the factory was in operation, was 3,680 lb., the proportion of solid camphor to camphor oil being approximately 2:1.

*Cost of Production.*—The estimated cost of production, excluding the cost of growing the trees was Sh. 2 per lb. of crude solid camphor, i.e. Sh. 1 for manufacturing costs, 75 cents for capital costs (factory only) and 25 cents for transport to the nearest port. In calculating these costs no allowance was made for the value of the camphor oil produced which was regarded as an unsaleable by-product. Actually this oil was eventually sold for 50 cents per lb.

In a redesigned factory run as a long-term undertaking the cost of production could probably be cut to well below Sh. 2 per lb. by the reduction in labour costs and the writing off of capital over a longer period of years.

## Observations on Plant and Machinery Used

The following faults became evident as work proceeded: (i) Power: At least 15 h.p. per chipper should have been provided. (ii) Chipping machines: The shutes to chippers should have been stronger and reinforced at the angles. The vibrations caused in these machines by the shock of 4,300 blows per minute from the knives was severe. The slots in the cutter disc should have been slightly larger to give a freer passage for the chips passing through the disc. The lack of a spare machine was felt. Owing to the vary hard work to which these machines were put the life of the knives was only eight weeks, and each had to be resharpened after four hours work. (iii) Condensers: The inner box and baffles should have been of heavy galvanized sheeting instead of $\frac{1}{32}$ in. The joints should have been welded and not soldered. Stiffening plates were needed at the points where the bolts for securing the lifting handles enter. A fifth, and even a sixth, water-cooled baffle would have been an advantage. (iv) Water supply: trouble was experienced through lack of a third, or reserve, water pump. The feed pipe carrying cooling water to the seven condensers should have been larger than 3 in. Where water temperatures are higher than at Lushoto,* provision would have to be made for obtaining the maximum cooling effect possible by (1) increasing the quantity and rate of flow of the cooling water, and (2) increasing the number of water-cooled baffles in the condensers.

## Valuation and Quality of Camphor Produced

*Valuation.*—A report from Messrs. Whiffen and Son, Ltd., received in January, 1943, gave the estimated London value of the camphor, as received, as Sh. 5/5d. per lb. for crude solid and 6d. per lb. for crude oil.

*Quality—Crude solid camphor.*—An abstract from a report from the same firm, received in January, 1944, showed that the percentage of pure camphor in the crude solid, as shipped, was 80 per cent, the balance being made up, approximately, of 10 per cent oil and 10 per cent moisture. The refined camphor was of B.P. quality with a melting point of 174-175°C.

* The following are typical records taken at the factory during the hot and the cool seasons:—

| | Cooling water temperature | |
|---|---|---|
| | To condensers | From condensers |
| Hot weather—March .. | 66·0°F. | 76·8–82°F. |
| Cool weather—July .. | 56·4°F. | 72·6°F. |

*Crude camphor oil.*—The results from fractional distillations carried out by Messrs. Whiffen and Son, Ltd., were as follows:—

Fraction 1. (160°C.) 1 per cent, principally pinene and camphene.

Fraction 2. (160-170°) 0·2 per cent, principally pinene.

Fraction 3. (170-180°) 8·2 per cent, the dipentene (limonene)—cineole fraction.

Fraction 4. (180-190°) 10·2 per cent, similar to 3, but contains small amount of camphor.

Fraction 5. (190-200°) 4·5 per cent, similar to 4, but camphor content much higher.

Fraction 6. (200-210°) 40·7 per cent, almost solid, consisting almost entirely of camphor with terpineole and borneol in minor amounts.

Fraction 7. (210-220°) 14·5 per cent, solid and similar in composition to 6.

Fraction 8. (220-225°) 4·2 per cent, semi-solid because of very high camphor content; similar in general characters to 6 with addition of safrole in small amount.

Fraction 9. (225-230°) 2 per cent, strong odour of safrole but general characters (optical rotation, etc.), indicate percentage in fraction not great.

Fraction 10. (230-235°) 2·2 per cent, similar to 9 and theoretically should contain most of the safrole; indications that borneol or isoborneol present in quantity.

Fraction 11. (235-245°) 3 per cent, similar to 9 and 10, and contains safrole together with sesquiterpenes and a phenol.

Fraction 12. (245-260°) 3 per cent, principally sesquiterpenes together with a phenol.

Residue (260°) 6·2 per cent, principally sesquiterpenes and di-terpene.

Considering the results as a whole, the main camphor fractions represented rather over 60 per cent of the whole oil and consisted very largely of camphor which could be readily separated by pressing, the filtrate being concentrated or frozen to obtain camphor. Safrole from fractions 9–11 was only present to a small extent, certainly to not more than 4 per cent of the oil. It is of interest to record that earlier work on camphor oils produced in East Africa stated that no safrole was present (this was probably due to the oil having been derived by distillation of leaves, twigs and small branches whereas the bulk of the oil produced at the Lushoto factory was distilled from mature wood).

## The Prospects for a Camphor Industry in East Africa

There is no doubt that the true camphor tree, *Cinnamonum camphora*, will thrive in parts of East Africa, particularly in the Lushoto District of West Usambara where it was established 35 years ago. It has also been shown that the manufacture of crude solid camphor and camphor oil can be successfully undertaken on a commercial scale in East Africa. The prospects for a camphor industry, therefore, depend almost entirely on ability to compete in price with the natural product of the Far East and the synthetic product of Europe and America. What the post-war price of camphor will be it is impossible to foretell. The c.i.f. price of Japanese crude camphor, which stood at Sh. 2/6 per lb. in 1920, had fallen to Sh. 1/6 per lb. in 1939. The pre-war price of Japanese camphor oil was only Sh. 65 per cwt. The value of East African camphor oil would depend largely on its safrole content and this is likely to be low if the oil is distilled from leaves and twigs under a coppicing system.

Since no large camphor forests exist in East Africa, the prospect of establishing a camphor industry within a reasonable period must lie in the exploitation of (1) short-term bush-camphor cut on a coppicing system, or (2) one of the camphor-yielding herbs, such as *Ocimum kilimandscharicum*. With regard to the first, according to Eaton (1912), closely planted camphor in the form of hedges (700 plants per acre), pruned two or three times per year, should yield from the third year approximately 15 tons of prunings per acre per annum, or 180 lb. of crude camphor. Whether such a yield is obtainable in East Africa and, if so, whether it would be profitable, cannot be judged until the comparatively large area of bush camphor planted at Lushoto by the Tanganyika Forest Department in 1943–44 is fit for sampling. On the assumption that a yield of 180 lb. of camphor per acre per annum could be realized and a price of Sh. 1/6 per lb. obtained for it, the return would be £13/10 per acre on the basis of c.i.f. or, say, £12/10 f.o.b. The cost of establishing bush camphor at Lushoto (excluding cost of land and European supervision) was approximately Sh. 105 per acre in the first year (1943) including all nursery costs. In the second and third years the cost of weeding would amount to approximately Sh. 10 per acre per annum, assuming that squatters were allowed to intercrop the land, thus reducing the cost of weeding.

With regard to the prospects for *Ocimum* camphor, little can be said until further trials with this crop have been carried out. In Kenya, Beckley has obtained 0.2–0.6 per cent of oil from fresh *Ocimum kilimandscharicum* and 15–25 per cent solid camphor from this oil by freezing. At Amani, Glover, working with the same species, in flower, reported only 0.024 per cent of oil plus 0.017 per cent of solid camphor. In another trial he obtained 0.1 per cent of solid camphor and only traces of oil. In the Sudan the same species of *Ocimum* has been reported as yielding 5.5 per cent oil from air-dried leaves, which on cooling to −5°C. gave 62 per cent of solid camphor by compression and filtration while it was estimated that a further 15 per cent remained in solution in the oil, making 77 per cent in all.* Another report from the Sudan gives the yield as 4 tons of "hay" per acre from which a yield (estimated) of 50 kilos of solid camphor was obtainable. In Russia, the yield of oil from *O. canum* var. *camphoratum* is said to be between 0.46 and 0.56 per cent from whole fresh plants and between 2.0 and 2.5 per cent from dried plants. A marked seasonal variation was also observed; thus, oil from plants harvested in August contained 47 per cent camphor, while October plants gave 74 per cent.

It would therefore appear from these reports that the yield of oil, and the camphor content of the oil, from *Ocimum* species is subject to considerable variation depending on time of harvesting and, probably, on other factors. A marked difference has been observed by Beckley† in the type of growth exhibited by *O. kilimandscharicum*—possibly inherent differences related to the yield of oil and its camphor content. The possibility of producing high-yielding forms by plant-breeding and selection would appear to be well worth investigating.

This account of emergency war-time camphor production in East Africa would be incomplete without a tribute to those members of my staff who were responsible for designing, erecting and running the factory. In particular I wish to mention P. J. Greenway for reconnaisance surveys; F. J. Nutman for carrying out laboratory and pilot-plant experiments, assisting in the design and erection of plant and machinery and taking charge of the factory during several difficult months; T. V. Greenwood for advising on design and for erecting pilot-plant and factory; J. Glover for carrying out distillation experiments; R. E. Moreau for drawing up an accounting system and preparing financial statements; and A. W. Ellis who took charge of the factory from September, 1942, and ran it most ably until August, 1943, when he wound up its activities. Apart from my own staff, I am greatly indebted to the Chief Mechanical Engineer of the Tanganyika Railways and his staff for very considerable assistance, without which the factory could not have been built or operated.

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* Information supplied by Imperial Institute *in litt.*

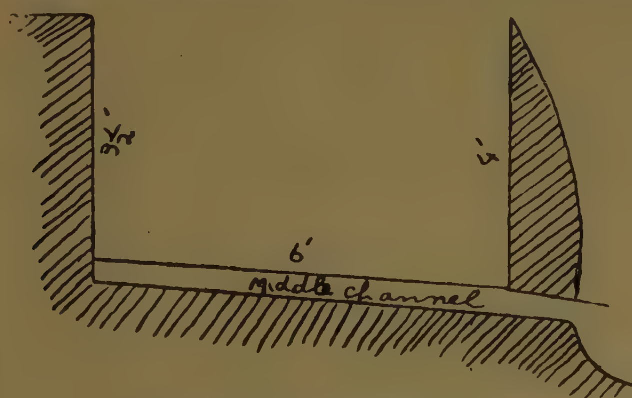
† *In litt.*

# THE MAYA DAS METHOD OF COMPOSTING

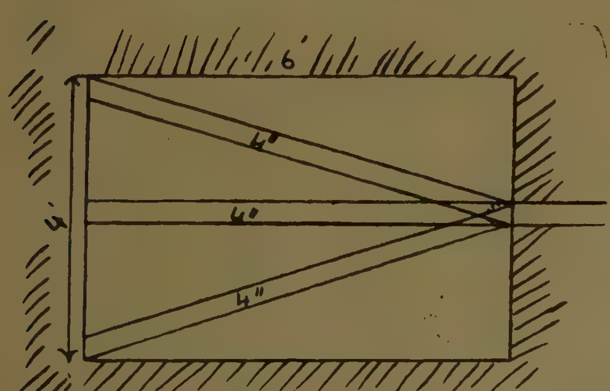
[We have received from Lt.-Col. C. A. Thornton, formerly resident in Kenya and now serving with the 18th Royal Garhwal Rifles, India, a copy of a circular on manure making in Indian villages, which we print below. Mr. Maya Das, the originator of the method, is Director of Agriculture, United Provinces, India.—*Ed.*]

*Size of Pit in the New Process.*

A pit 6 ft. long, 4 ft. broad and 3½ ft. deep is first prepared. The floor of the pit is then dressed to slope gently by 6 in. towards one end, so that at one end the depth of the pit is 3½ ft. and at the other 4 ft. Three small channels, 4 in. in width and 4 in. in depth, are then made along the length of the pit, two of them starting from the corners and the third from the middle of the shallower end, each leading towards an air hole, 4 in. in diameter, in the centre of the base of the deeper end. (*See* Fig. 1.) The channels are provided with a common air inlet by boring a hole 4 in. in diameter in the wall. It is suggested that the manure pits be prepared on the embankments of village tanks where the necessary slope to make an inlet for air is already available. Failing this, a small trench adjoining the manure pit 4 ft. deep, should be dug to facilitate the making of an air hole. The channels and the air inlet are covered loosely with small stones or pieces of broken earthenware pots, over which the material is packed. The channels and the inlet provide free communication with the air and also serve to drain away any surplus water from the compost pit. A piece of clay pipe or thick hollow bamboo may be fitted in the inlet to keep the earth above from falling and choking the passage. The rise of temperature due to the decomposition of the organic material causes the warm air in the compost to rise and fresh air is drawn




Sectional view of compost pit.




View from top.

FIG. I

through the inlet. The provision of air channels in the compost pit is the essential feature of the new method.

*Charging the Pit.*

A six-inch layer of organic refuse, e.g. leaves, trash, etc., is spread uniformly on the floor of the pit and thoroughly wetted with a thin slurry of cattle dung (one part cattle dung to three parts water), followed by urine earth (one basket), ash (one handful) and a small quantity of old manure to act as activator. Over this, another layer of refuse is put and slurry, urine earth, etc., are added. The process is repeated till the material rises to a height of about 4 ft. above the ground level (*see* Fig. II). The pit is then left untouched for 14 days.

*Turning.*

The contents of the pit are turned over once after the first 14 days, every fortnight thereafter during the first two months and once a month subsequently. When turning, the entire material is shovelled out of the pit and put to one side. It is put back immediately, placing the upper portion at the bottom of the pit and bringing the lower portion to the top. At the next turning the same process is repeated, and so on. In this way the upper and the lower layers are exposed, alternately, to the atmosphere. Care should be taken to sprinkle water at each turning and to keep the composting material fairly wet. At each turning the small channels and air inlet should be repaired if necessary.

The compost is usually ready for application to the fields in three to four months in the plains.

*Procedure to be followed in the Hills.*

Compost pits of the above specifications can easily be prepared in the hills. The channels on the floor of the pit should be covered by flat stone, and the air inlet should open out into the lower terrace. Turning over of the material, particularly in localities at elevations of over 4,000 ft. above sea level, should be done once a month. The compost is usually ready for application to the fields in eight months time.

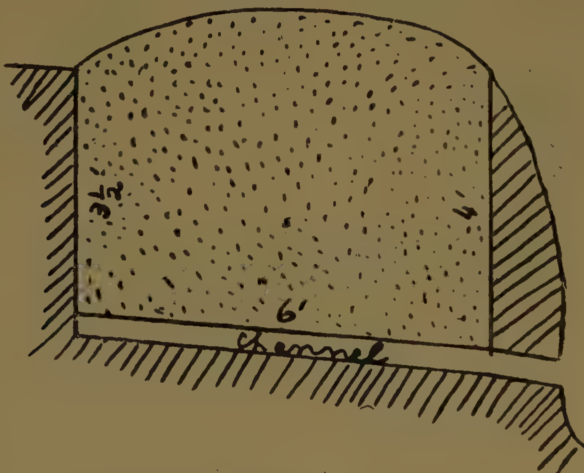



FIG. II

Sectional view with material filled in the pit.

By far the greatest danger to civilization the world over is denudation and erosion. In North Africa, and parts of Eastern Europe, in Mesopotamia, in huge districts of China, civilizations have in the past been clean wiped out (like Ozymandias) by erosion, and the process is going on at a most alarming rate in South Africa, in Australia, and in the United States—to give some of the more salient examples. The cause in America has been largely continuous grain cultivation, due to European demands. W. Beach Thomas in *The Spectator.*

## LAND UTILIZATION

The period of exploitation of the best soils in the best rainfall regions is rapidly drawing to a close, and increasing use must be made in the future of soils which are deficient in one or more respects, providing the rainfall is adequate and these deficiencies can be overcome.

Professor J. A. Prescott, in *A Soil Map of Australia.*

# COMPOSITION AND FEEDING VALUES OF GREEN MAIZE, MILLET AND BULRUSH MILLET CUT FOR SOILING PURPOSES

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory

*(Received for publication on 10th November, 1944)*

In the long dry seasons of this Territory the problem of providing green succulent foods for feeding to high-producing animals, such as heavy milk-producing cows, is very important. Such green foods provide the very necessary carotene (a precursor of vitamin A) required to maintain body reserves at this time of the year when the natural herbage contains practically none. Carotene is converted by farm animals into vitamin A and the maintenance of an adequate reserve of this vitamin is necessary to ensure that high-producing animals remain in sufficiently good health to continue in production at a high rate. Shortage of this vitamin will lead to skin disorders, possible eye troubles, retard the normal growth rate and interfere with reproduction. In addition, the secretion of large volumes of milk, which contains vitamin A and carotene, causes a large drain on the liver reserves of this vitamin. Actually, when the liver reserves become low the quantity of carotene and vitamin A in the milk is curtailed and the nutritive values of the milk and butterfat are correspondingly reduced. Besides the provision of vitamin A, green foods exert a very beneficial effect on the tone of the digestive system, thereby promoting the better utilization of the dried roughages which form the bulk of the ration in the dry season.

Whenever water supplies make it possible, green crops are grown under irrigation in the dry season by European farmers in this Territory. Maize is probably the crop grown most frequently and the green crop is cut and carted to the stock when it has reached the flowering stage or as soon as the cobs become milky. Lucerne probably comes second to maize in popularity, but the feeding values of green lucerne have already been reported upon [1] and so it was decided to get more information about the composition and feeding value of maize when cut in the green immature state for feeding to live stock. The opportunity was also taken to get comparative values for green millet and green bulrush millet.

In a previous article [2] it was found that the stover from bulrush millet was more fibrous and consequently less digestible than maize or millet stovers and so it was considered desirable to cut the green bulrush millet at a slightly earlier stage than the maize and millet crops. Lignification of the fibre in plants occurs at a more rapid rate about the time of flowering or of the emergence of the flower buds and it was considered important, in the case of bulrush millet, to cut and feed the crop before any marked lignification of the fibre had made it less digestible. Because of this the bulrush millet was cut when it was 4–6 feet high and when the flowering heads were just emerging. The crop had suffered from an early drought period but had subsequently grown well. The seeds had been sown thickly to encourage tall growth and when the green crop was cut the stems were still soft. The maize crop had also been planted thickly and was cut at a little later stage of maturity than the bulrush millet, when the plants were 6–7 feet high and when the cobs were approaching the milky stage of development. The maize plants were at the stage most suitable for ensiling. Owing to the time taken to carry through the digestibility trials, the millet crop had become slightly more advanced in maturity than the maize, the plants were 6–7 feet high, and seeds were forming but had not become firm.

All these crops were grown during the wet season and may, therefore, not represent exactly the compositions and feeding values of plants grown under irrigation during the dry season but the results obtained earlier with lucerne [1] suggest that the differences, on a dry-matter basis, would not be very marked provided the irrigating water was sufficient to maintain good growth. In the dry season it is to be anticipated that the dry-matter content of the green crops would be higher than when grown during the rainy season.

The compositions of the three crops are given in Table I. The samples for analysis were obtained by taking an aliquot from the freshly cut and chaffed crop prepared daily for the digestion experiments. These samples were dried to determine the dry-matter contents of

the daily rations and the dry-matter residues were collected, bulked and ground together to form the analytical samples. The average figures for the dry-matter contents of the crops, as weighed out for the digestibility trials, were 16.8, 29.2 and 12.3 per cent respectively for the green maize, millet and bulrush millet.

TABLE I

COMPOSITIONS OF GREEN MAIZE, MILLET AND BULRUSH MILLET (Dry matter basis)

| | Maize | Millet | Bulrush millet | American maize | American Kaffir fodder |
|---|---|---|---|---|---|
| Stage of maturity | (1) | (2) | (3) | (4) | |
| Crude protein | 8·83 | 7·62 | 13·68 | 8·1 | 8·0 |
| Ether extract | 0·91 | 1·50 | 1·72 | 3·0 | 2·0 |
| N-free extract | 54·83 | 50·48 | 42·25 | 58·8 | 50·8 |
| Crude fibre | 28·04 | 32·60 | 27·46 | 24·6 | 32·7 |
| Total ash | 7·39 | 7·80 | 14·89 | 5·5 | 6·5 |
| $SiO_2$ | 2·29 | 3·18 | 6·01 | — | — |
| $SiO_2$-free ash | 5·10 | 4·62 | 8·88 | — | — |
| CaO | 0·967 | 0·977 | 0·983 | — | — |
| $P_2O_5$ | 0·580 | 0·539 | 0·724 | — | — |
| $K_2O$ | 1·979 | 1·991 | 2·446 | — | — |
| $Na_2O$ | 0·321 | 0·365 | 0·465 | — | — |
| Cl | 0·376 | 0·339 | 0·525 | — | — |

(1) Cobs milky, 6–7 ft. high.
(2) Seeds forming but still soft, 6–7 ft. high.
(3) Flowering heads emerging, 4–6 ft. high.
(4) Cobs at milky stage.

The first point of interest about these figures is the relatively high crude-protein content of the bulrush millet, but higher protein contents are characteristic of immature plants and the level falls as maturity is reached. The early state of cutting the bulrush millet has certainly influenced its crude-protein content and is also responsible for its relatively low crude-fibre content. The figures recorded for green maize and millet agree with the compositions of American-grown maize with its cobs at the milky stage and for kaffir corn which was showing flowering heads. [3]

Reference to the previous article [2] will show how great a difference exists between the compositions of these green plants and the stovers left from them after the grain has been harvested. The main changes are a reduction of the crude-protein content by half and an increase in the crude fibre.

The mineral contents are satisfactory, and the relatively high lime contents are of especial value in this Territory.

*Digestibility Trials.*—As already mentioned, the plants were collected daily from the field and brought to the laboratory early in the mornings. The plants were chaffed and thoroughly mixed to facilitate sampling, to make it possible to feed more uniform rations to the experimental animals, and to ensure, as far as possible, that the animals consumed the same amounts of nutrients daily. The green fodders were fed unmixed with other roughages or concentrates to adult male native sheep and, after the animals had become accustomed to the rations, they were harnessed and put in the metabolism crates for five days before the actual experimental collection of faeces began. Ten-day collecting periods were carried through, during which the rations were eaten completely and no digestive or other disturbances interfered with the course of the trials.

With each green food examined two animals were used to get the average digestibility coefficients summarized in Table II. The coefficients obtained with each pair of animals agreed well and only slight differences between the individual sheep were recorded for the digestibility coefficients of the ether extract in the green maize and bulrush millet trials. Table II gives the average digestibility coefficients as reported by Henry and Morrison [3] for green maize at milky stage of cob development.

TABLE II

DIGESTIBILITY COEFFICIENTS OF GREEN MAIZE, MILLET AND BULRUSH MILLET

| | Maize | Millet | Bulrush Millet | American Maize |
|---|---|---|---|---|
| Crude protein | 57·02 | 56·65 | 66·66 | 62 |
| Ether extract | 20·60 | 67·35 | 48·00 | 76 |
| N-free extract | 72·76 | 64·29 | 70·78 | 77 |
| Crude fibre | 66·60 | 68·13 | 74·10 | 64 |
| Soluble ash | 65·91 | 63·30 | 71·81 | — |
| Dry matter | 68·73 | 64·98 | 70·85 | 70 |
| Organic matter | 68·88 | 65·06 | 70·73 | — |

As would be expected, these green fodders are all well digested and the more immature bulrush millet proved to be the most digestible. It is interesting to see that the crude-fibre constituents were better digested than in the American samples of green maize but that the crude proteins in the local maize and millet samples were less efficiently dealt with. The nitrogen-free extracts were also less well digested in the present trials and the same was true of the ether extracts, particularly in the maize and bulrush millets.

The digestible nutrients and starch-equivalent values have been calculated and are shown in Table III.

TABLE III

DIGESTIBLE NUTRIENTS AND STARCH-EQUIVALENT VALUES OF GREEN MAIZE, MILLET AND BULRUSH MILLET (per 100 parts dry matter)

| | Green Maize | Green Millet | Green Bulrush Millet |
|---|---|---|---|
| Stage of maturity | (1) | (2) | (3) |
| Digestible crude protein | 5·03 | 4·32 | 9·12 |
| „ ether extract | 0·19 | 1·01 | 0·83 |
| „ N-free extract | 39·89 | 32·45 | 29·90 |
| „ crude fibre .. | 18·67 | 22·21 | 20·35 |
| „ organic matter | 63·78 | 59·99 | 60·20 |
| Starch equivalent .. | 47·39 | 41·74 | 44·47 |
| Nutritive ratio .. .. | 1 : 11 | 1 : 13 | 1 : 6 |

(1) 6-7 feet high. Cobs milky.
(2) 6-7 feet high. Seeds soft.
(3) 4-6 feet high. Flowering.

These figures show how rapidly the digestible crude-protein content falls as maturity is reached, and indicate that the digestible protein content is likely to be high if the green crops are cut before seed heads start to emerge. Actually these crops are usually cut just after the seed has begun to form because, at that stage of development, the maximum yield is obtained whilst the falling off in feeding value with approaching maturity has not gone unduly far.

Comparison with the figures for green grass samples [4] shows that the energy values of these green crops are as high as those in grass up to 15 inches high. The digestible protein in these green fodders, though not so high as in young grass from the best local grasses, compares well with the levels recorded for the majority of grasses as they approach the hay-making stage.

Comparison with the figures for green lucerne samples [1] shows that these green fodders have approximately the same starch-equivalent values as recorded for green lucerne, but they have very much smaller contents of digestible protein.

It is seen, therefore, that either maize, millet, or bulrush millet if grown under irrigation in the dry season, would form a valuable green supplement to the diets of high-producing stock. These green fodders should, however, be fed with concentrates which will supply adequate amounts of digestible protein because they are not rich in this valuable constituent if cut after the seeds have begun to form. A much higher digestible-protein content is obtained if the crops are cut before they begin to form seeds, but the time of cutting must be left to the judgment of the farmer; cutting too late gives a poorer fodder, whilst cutting too early gives a smaller yield per acre. Somewhere between the time the plants flower and the time the seeds reach the milky stage of development will probably be found the best point for cutting and feeding these green fodders.

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[2] French, M. H.—*E.A. Agric. Jour.* 9 (1943-44), 88.
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[4] French, M. H.— *Emp. J. Exp. Agric.* 9 (1941), 23.

## LETTER TO THE EDITOR

### MEAD

*The Editor, East African Agricultural Journal.*

Sir,

May I congratulate W.V.H. for his short note on Mead, which appeared in this Journal for October, 1943. The C.B.E. has often been awarded for a less valuable contribution to civilization. I have found Mead an excellent drink, fully the equal of, though quite different from, a light table wine. As W.V.H. indicated, the only difficulty in making it lies in keeping it long enough. I have recently sampled a bottle that, by the exercise of great self-restraint, I had kept for a year. Both in character and vinosity it was a great improvement on Mead of the same vintage (or should one say apiage?) that had been kept for six months only. I hope to be able to keep some long enough to ascertain the best age at which it should be drunk, which quite possibly may be, as with wines of similar strength, some three to seven years. May I conclude with a quotation from a poem by James Howell, sometime Fellow of Jesus College, Oxford, and Clerk of the Privy Council in 1640:—

"The juice of Bees, not Bacchus, here behold,
Which British Bards were wont to quaff of old;
The berries of the Grape with Furies swell,
But in the Honeycomb the Graces dwell."

Yours, etc.,

22nd April, 1945. B. LOVER.

# BUKURA NATIVE AGRICULTURAL SCHOOL, NYANZA PROVINCE, KENYA

By E. L. Bradford, Department of Agriculture, Kenya

(*Received for publication on 3rd May, 1945*)

Bukura Training Centre, originally a Seed Farm and Experimental Station, has passed through many vicissitudes, but its status has been primarily an African agricultural training centre. Originally the training was for Native Agricultural Instructors, farm headmen, etc., and the course extended over a period of four years but now that departmental staff replacements only are required the training has been extended to suitable candidates anxious to study agriculture in their own interests, to fit them for more skilful management of their own land in due course.

The farm comprises 318 acres at an altitude of 4,850 feet, in a high rainfall area (60 in to 70 in.), having two rainy seasons a year—March–June and August–November. The soil of the toplands is poor, consisting of loose ironstone (murram) subsoil and shallow red top soil with little humus, whilst the soil towards the base of the ridges is deeper and richer, varying from black forest soil to red loams. Thus much of the agricultural instruction comprises cultural training on poor soil and compels students to employ a modicum of scientific application. The climatic conditions are fairly representative of many parts of Nyanza Province and of parts of Kericho and the Nandi Districts—from which areas the pupils are selected for training. A swamp forming one boundary of the farm, of rich alluvium soil, is used for rice cultivation and experimentation, and all such work, including swamp clearance and bunding, is carried out by the pupils.

All land is worked on the contour and with proper rotations being followed the long-term hay and root crops (S. Potato and Cassava) and the pastures enhance the principle of strip-cropping. The contours may be started merely as ridges on which live wash-stops are planted (such as bananas, Uganda napier grass—not to be confused with the rank coarse Kenya or Sudan type of napier grass—or, alternatively, narrow based terraces). Whichever system is followed at the outset these contours are steadily built up, by correct ploughing, into broad base terraces, and, in due course, when the pasture is gradually rotated one contour at a time with the arable, the whole of the holding, both pasture and arable, becomes broad base terraced.

A system of collective farming with five ex-labourers and their families and stock is being tried out on a 50-acre block—with land available for extension if necessary—but this is only in its infancy, and little can yet be said of the project. The Centre is now training up to 60 pupils at a time and the course covers a two-year period. Three teachers are sent annually from Missions to take a one-year course in theoretical and practical agriculture to prepare them as agricultural teachers at their respective schools when they return. The pupil's standard of education varies from standard III to standard VI and this variability in educational qualifications makes it difficult to carry along together the 60 apprentices throughout the two-year course. To remedy this defect as much as possible evening classes are held in the three R's for the more backward lads.

The selection of candidates for Bukura is made by District Agricultural Officers throughout the Province on a quota basis. Young lads who have just left school are discouraged, as they will still be too immature at the end of the course to become Instructors; few of them immediately upon leaving school have decided upon an ambition in life, and until they have decided against while collars and clean hands it is a waste of money and time training them to live profitably on the land. Selections are, therefore, generally made from temporary Assistant Agricultural Instructors who have shaped well in the preliminary canter, or natives who have already started to farm their own land and have shown a desire to study the subject in more detail. During training, apprentices receive Sh. 4 per month pocket money and are given uniforms and blankets. After 4–5 months on probation during which period they have had time to settle down and show any likely promise and ability, the inevitable weeding out process is accomplished, and those incapable of benefiting are returned to their own homes.

Originally the pupils were trained on the Seed Farm and experimental plots, and a few cows and oxen were kept to give a mixed farming bias, but in 1937 the system was changed in favour of separate mixed farms, the number of which has steadily increased until to-day there are 18 complete. The acreages of these small mixed farms vary from 1½ to 10

acres, for besides training pupils thereon, statistical data is required to determine the requisite size of holding to meet the food and financial requirements of families varying in numbers, and families varying in status and standards of living. Each holding is a complete unit comprising living quarters (burnt brick rondavels with well-thatched roofs*) kitchen, lavatory, food stores, milking sheds, calf pens, night *boma*, hedges, paddocks, contoured arable, etc. The stock (native selected animals) varies in number from one to six according to the size of the holding. Calves are, whenever possible, hand reared. The number of students resident on each mixed farm varies with the size of the holding—generally from two to four—and they represent a working family (such as a man, his wife, and one or two children of working age). Ploughs, scufflers, and teams of oxen are allocated to blocks of holdings, and each farm has the use of the team for one day at a time. The oxen are distributed amongst the mixed farms and constitute part of the holdings' stock.

Although the principle of mixed farms is still in the melting pot, and may or may not be decided upon in the future as the best method for African agriculturalists, the fact remains that it offers many training advantages over other systems in that—

(*a*) slackers are easily spotted by the condition of their farms;

(*b*) pupils are given scope for initiative in regard to all farming operations and the crops planted within reason, and provided correct crops are grown as stock feed etc.;

(*c*) greater interest is taken in the work as it is more varied; they live on their mixed farm and can consider it theirs for two years;

(*d*) the practical work includes all farming operations such as milking, hand rearing of calves, stock feeding, ploughing, cultivating, fencing, soil conservation methods, mensuration, planting, harvesting and seed selection, building, thatching, nursery work, rotations, rotation of arable and pasture;

(*e*) co-operation in the use of oxen, implements, etc., which would be too expensive for one family to own until well established, is introduced;

(*f*) mistakes made by pupils in agricultural practices are easily observed in due course by the individuals concerned and can be rectified;

(*g*) each farm is self-supporting as regards food. The only rations issued are salt, paraffin, soap, and ghee;

(*h*) pupils have to think ahead; they also have to think for themselves.

Having completed one year on his farm, the pupil, if he has proved himself worthy, takes charge of that farm in his second year and initiates the first year students under his control. He becomes the prefect, wears the chevron, and has the responsibility of ensuring that sufficient food is grown for the residents, and has the kudos of any profits made from cash crops. Other training includes rice cultivation, tree, hedge, and fruit nursery work, line levelling, the use of the Abney quick-set level, terracing, mensuration and this year will also include rough farm carpentry, elementary blacksmithing, and soldering, burnt brick making, bricklaying, dairying (butter and ghee making). When transport can be made available it is proposed to give instruction in co-operative marketing.

The theoretical instruction embodies such subjects as the care and management of stock and pastures, stock diseases, hand-rearing of calves, etc., and the curriculum, prepared by my predecessor, has now been published in book form† whilst elementary agricultural theory is taught from a compilation of notes by previous officers in charge of Bukura, augmented and revised annually. These may also, at some future date, be considered sufficiently comprehensive to warrant an appearance in printed form. A strong bias towards mixed farming and intensive farming is inculcated, with emphasis on the facts that effective soil conservation measures, the maintenance of adequate numbers of stock, general crop rotations, systematic rotations of pasture with arable, and seasonal manuring are the surest ways of maintaining and improving soil fertility, as well as eliminating shifting cultivation and lengthy uneconomical fallowing. At the same time diversified farming enhances the nutritional level of the family diet. These aspects have been dealt with in greater detail in a previous article in this Journal.‡

* *See* "Rondavel Hut Construction" by Graham, *E.A. Agri. J.* of Jan., 1939.

† "Elementary Live Stock and Pasture Management" by M. D. Graham with a chapter on Cattle Diseases by R. A. Hammond.

‡ "An Experiment in Native Mixed Farming in the Nyanza Province of Kenya" by M. D. Graham, October, 1941.

Trials and experimental work, in which the pupils participate in that much of it is carried out on the mixed farms, covers hay varieties, paddock hedge varieties, pasture grass varieties, rice trials—varieties, spacing, best time of planting, age of seed for planting, etc., live wash-stops for contour planting (and here I must add that bananas make excellent wash-stops with the constant cutting and laying of the trash; besides being dual purpose and therefore popular).

Crops grown are intentionally diversified for instructional purposes and comprise *inter alia* maize, sorgham, wimbi, cassava, sweet and English potatoes, field peas, cow peas, C.W. beans, soya beans, groundnuts, hays, vegetables—with onions, etc., as a cash crop.

The daily routine time table of the four students on a mixed farm is somewhat as follows, with duties alternating daily:—

| | Pupil A | Pupil B |
|---|---|---|
| Sunrise | Milking and hand-feeding of calves. | Practical work. |
| 8 a.m. | Breakfast | — |
| 8.30 a.m. | School. | Practical work. |
| 10 a.m. | Cooking. | — |
| 12 noon | Lunch. | — |
| 1 p.m. | Seasonal practical work on holding. | School. |
| 2.30 p.m. | School. | Practical work. |
| 5 p.m. | Football or scout training. | — |
| 6 p.m. | — | — |

| | Pupil C | Pupil D |
|---|---|---|
| Sunrise | Cooking for the holding. | Rice or soil conservation instruction; or Bricklaying or Carpentry all day. |
| 8 a.m. | — | |
| 8.30 a.m. | Practical work. | |
| 10 a.m. | School. | |
| 12 noon | — | — |
| 1 p.m. | Practical work. | — |
| 2.30 p.m. | School. | — |
| 5 p.m. | — | Football. |
| 6 p.m. | Milking, etc. | — |

In the second year pupils are sent out into the native reserve for one or two periods under Senior Native Agricultural Instructors to get some experience of the work in the districts; to apply their knowledge in a practical manner; and to gain confidence and experience in the instruction of their fellow African. It also enables those who may eventually become Agricultural Instructors to appreciate the difficulties and problems they are likely to meet with in due course, and prepares them for the answers. In the past, when transport was available, pupils visited such centres as Sangalo Veterinary Station, Maseno Agricultural Centre, the principle market centres, etc., to glean some useful knowledge on what goes on around them and to broaden their ideas. No examinations are set either annually or at the end of the course, but permanent records are kept of character, ability and capabilities, initiative and possibilities of each apprentice; how they have shaped in school, in the practical work on the small holdings, their care of the stock, holdings, etc., and their tutorial work in the Reserves. Such reports are compiled periodically at staff meetings comprising the Officer in Charge, a Makerere-trained teacher, a Makerere-trained Agricultural Assistant, the Senior Agricultural Instructor of the District (in respect of Reserve work), two resident Agricultural Instructors, and two artisan instructors.

It is probable that in the near future it may be necessary to amend the curriculum in order that those showing most promise as future Agricultural Instructors can be coached for such work, and their training intensified in certain specialized subjects, whilst those showing less ability and initiative can be given a more general grounding in stock, agriculture, rough craftsmanship, etc., with less specialization in subjects which will not affect them to any appreciable extent when they return to their own farms.

Spinning and weaving is taught to the wives of the teachers who are sent here for agricultural instruction, as well as to Instructors' wives and women living nearby. There are now two looms, three large spinning wheels and two small spinning wheels; the instructress being the wife of the resident Agricultural Assistant. This little industry is very popular and those who purchase their wool keep the products of their own industry. The Scout movement is also represented at Bukura and the annual rally camp makes a break from the usual routine of the Centre. It gives them other interests in life, and has a beneficial moral effect, besides the splendid training it offers.

A film has just been taken by the Military Information Office for release in England. All activities at the Centre are depicted whilst a story theme runs throughout the picture. It is to be hoped that a copy will be obtained for African display also, as it has educational possibilities as well, more especially so now that the Rehabilitation Officer has visited and seen the scope and possibilities of post-war training of the African soldier at such Institutions as Bukura.

# IMPROVED PLANTING MATERIAL OF THE TUNG TREE : A PROGRESS REPORT

By C. C. Webster, Tung Experimental Station, Department of Agriculture, Nyasaland

*(Received for publication on 25th June, 1945)*

The nature of the variation in flowering habit and yield which is found in a seedling plantation of *Aleurites montana* has been described in two previous papers in this Journal. [1] [2]. Briefly, some 40 to 50 per cent of the trees are predominantly male and therefore bear very little fruit, while the remainder, which are known as "bearers", produce a much higher proportion of female flowers and consequently set very much more fruit. These facts are illustrated by the figures of Table I, which show the average yields per tree of a seedling plantation of 123 trees from three years old, when they began fruiting, to the tenth year. The plantation contained 48 males (39 per cent), and the very small contribution made by these trees to the total yield is readily seen from the second line of figures. There is considerable yield variation within the bearing trees, the majority giving only moderate yields, while a small proportion are exceptionally good. This can be seen from a comparison of lines 3 and 4 of Table I, and also from Table II, which shows the frequency distribution of the 75 bearing trees according to their yields in the tenth year.

TABLE I
YIELDS OF A SEEDLING PLANTATION OF 123 TREES
(Average yields in lb. dry seed per tree)

| Age in years | 3 | 4 | 5 | 6 |
|---|---|---|---|---|
| 1. All trees | 1·7 | 3·6 | 5·2 | 9·4 |
| 2. Forty-eight male trees | 0·1 | 1·0 | 0·5 | 1·2 |
| 3. Seventy-five bearing trees | 2·7 | 5·9 | 8·2 | 14·6 |
| 4. Twelve best bearers | 4·8 | 8·7 | 17·1 | 27·5 |

| Age in years | 7 | 8 | 9 | 10 |
|---|---|---|---|---|
| 1. All trees | 11·8 | 13·7 | 15·1 | 20·5 |
| 2. Forty-eight male trees | 2·0 | 2·3 | 2·7 | 5·2 |
| 3. Seventy-five bearing trees | 18·1 | 21·1 | 23·1 | 30·4 |
| 4. Twelve best bearers | 28·4 | 35·3 | 33·2 | 50·8 |

From the foregoing it will be seen that the selection of the best bearing trees from seedling plantations and their vegetative propagation by budding, or some other method, offers great possibilities of improving yields per acre, since by this means not only would the large proportion of males be entirely eliminated, but the whole plantation would consist of clonal material derived from only the best of the bearers. It was discovered some time ago that budding on to seedling rootstocks presented no difficulty, and so far propagation has been entirely by this method as no success has attended small-scale attempts to root cuttings, layers, etc.

TABLE II
FREQUENCY DISTRIBUTION OF 75 BEARING TREES ACCORDING TO YIELD IN TENTH YEAR

| Yield class, lb. dry seed | 0-10 | 10·1–20 | 20·1–30 | 30·1–40 |
|---|---|---|---|---|
| Number of trees | 4 | 12 | 27 | 15 |
| Yield class, lb. dry seed | 40·1–50 | 50·1–60 | 60·1–70 | 70·1–80 |
| Number of trees | 8 | 6 | 2 | 1 |

## SELECTION

The first step towards improvement was to discover the best trees in existing seedling plantations, and this has been done by examining the fields tree by tree, numbering individuals which appeared to be carrying an exceptionally heavy crop, and recording their yields for several years. Selection is based primarily on yield, which is much the most important factor, but such characteristics as the vigour and habit of the tree, and the percentage of seed, kernel and oil in the fruit, are also receiving consideration. This work was begun on a small scale in 1940 and has since been expanded from year to year. So far 662 selections have been made from a survey of plantations totalling just over 40,000 trees. The work of selection has been handicapped by the fact that most of the plantations of *A. montana* in Nyasaland are comparatively recent, and in 1940 there was only a few acres of this species which had begun to fruit. It would have been more satisfactory had it been possible to begin selecting from a large area in full bearing, but it was impossible to wait for this and a start had to be made with the younger material available. In consequence, trees of only four or five years old had to be selected for preliminary yield recording. One disadvantage of this is that, as young trees show considerable

seasonal variation in yield, a number of selections which bore heavily in their first recorded year have not subsequently maintained their early promise. There has also been some tendency to select precocious bearers and it is probable that many of the trees at present bearing most heavily in these young plantations will be surpassed in later years by slower maturing trees. It will consequently be necessary annually to re-examine the fields tree by tree for a considerable period and it will be some years before the best trees can be finally selected. In spite of these difficulties, however, a number of outstanding trees have already been found, several of which have given over 75 lb. of dry seed in a single season.

### Vegetative Propagation as Buddings

After several years of yield-recording the more promising of the selected trees are being propagated as buddings on seedling rootstocks and the resulting clones planted in field trials for comparison. Final selection will, of course, be based on the performance of the buddings rather than on that of the mother trees itself. At present 68 clones are under trial at the experimental station but less than half of these are yet in bearing, and in this paper only the earliest buddings, planted at the end of 1940, will be discussed.

The first field trial, planted in December, 1940, compares unselected seedlings derived from ordinary bulk seed, "selected seedlings" raised from open pollinated seed taken from four selected trees, and buddings of the same four selections on both *montana* and *fordii* seedling stocks. When this trial was planted the budded plots were planted with "budded stumps", i.e. seedlings 18 months old, budded in the nursery, cut back four inches above the bud patch and then planted out with the scion bud still dormant. In order that all plots should be similarly treated, the seedling plots were planted in the same way and only one shoot was allowed to grow from each seedling stump. Unfortunately, this experiment is planted on rather pool soil and the yields, shown in Table III, are on the low side. In the second year the buddings bore a few fruit and the seedlings scarcely any; in the third year buddings on both stocks gave significantly better yields than the seedlings but there was no difference between rootstocks or between the two types of seedling. In the fourth year the buddings on *montana* stock were significantly better than all other treatments, giving nearly three times the yield obtained from unselected seedlings. Buddings on the *fordii* stock were also better than unselected seedlings, but not superior to the selected seedlings. In order to compare vegetative growth, girth measurements have been taken annually at three inches above the union, and those taken at 3½ years after planting are summarized in Table III. The girth of both types of seedling is significantly greater than that of the buddings, and that of buddings on *montana* stock is greater than those on *fordii*. These differences in vigour can now be seen at a glance, the seedling trees being distinctly bigger than the buddings and the dwarfing effect of the *fordii* rootstock particularly evident. The *fordii* stock also results in a slightly shorter growing season than the *montana* stock. The yields obtained from the four clones used in this trial on the *montana* stock are shown in Table IV. The clone ZM13 was significantly better than all others in the fourth year. In passing it may be mentioned that seedlings of the candlenut tree (*Aleurites moluccana*) have also been tried as rootstocks for both *fordii* and *montana*, but although the bud patch "takes" and a short scion shoot grows out after cutting back the stock, the scion has always died after a few weeks and it seems clear that the species are incompatible.

Table III

Mean Yields, Lb. Dry Seed

| Age in years | | Buddings | | Seedlings | | Sig. diff. | |
|---|---|---|---|---|---|---|---|
| | | Montana stock | Fordii stock | Selected | Unselected | P=0·05 | P=0·01 |
| 2 | Per tree .. .. | 0·27 | 0·29 | 0·02 | 0·02 | — | — |
| 3 | Per tree .. .. | 1·85 | 1·69 | 0·89 | 0·69 | 0·36 | 0·50 |
| | Per acre* .. .. | 104 | 95 | 50 | 39 | — | — |
| 4 | Per tree .. .. | 6·72 | 3·70 | 3·06 | 2·35 | 1·41 | 1·95 |
| | Per acre* .. .. | 376 | 207 | 171 | 132 | — | — |
| 3½ | Girth, inches .. .. | 11·63 | 9·52 | 14·05 | 13·65 | 1·10 | 1·52 |

* All trials at the experimental station are planted at fifty-six trees per acre.

TABLE IV

MEAN YIELDS, LB. DRY SEED

| Age in years | | Clones | | | |
|---|---|---|---|---|---|
| | | ZM8 | ZM13 | ZH14 | ZF9 |
| 3 | Per tree .. | 1·75 | 1·90 | 2·50 | 1·25 |
| | Per acre .. | 87 | 107 | 140 | 70 |
| 4 | Per tree .. | 6·10 | 9·30 | 6·12 | 5·37 |
| | Per acre .. | 342 | 521 | 343 | 301 |

A second experiment planted at the station in December, 1940, compares intercropping during the first four rainy seasons with—

S: Soya beans, plants removed when harvesting beans;

M: Maize, trash buried after harvest;

V: Green manure crop of velvet beans dug in annually;

C: Cover crop of *Calapogonium mucunoides* intended to be permanent but which died out early in the fourth season owing to failure to set seed.

The whole of this trial is planted with buddings on *montana* rootstocks, the main plots being divided in order to compare five different clones. The yields from the four cultural treatments are shown in Table V. The consistent superiority of the soya plots appears to indicate an advantage from clean cultivation with a crop which does not take much from the soil. The *Calapogonium* plots, which received least cultivation of all, are the worst; while maize and velvet beans are intermediate. Several more years' records are required before definite conclusions can be drawn, but the indication seems to be that budded tung will require fairly thorough cultivation, at any rate in the early years, and a proper regard to the maintenance of soil fertility. Girth measurements show a similar superiority of the soya plots as regards vigour. The average yields obtained from the five clones under all cultural treatments, and also on the soya plots only; are shown in Table VI. In both sets of figures it will be seen that clones 14 and 10 are significantly better than the others, there being no significant differences between 14 and 10, or ZN24, ZM8, and ZF9.

TABLE V

MEAN YIELDS, LB. DRY SEED

| Age in years | | Treatments | | | | Sig. diff. | |
|---|---|---|---|---|---|---|---|
| | | Soya | Maize | Velvet | Calapog. | P=0·05 | P=0·01 |
| 2 | Per tree .. .. .. .. | 1·53 | 1·51 | 0·77 | 1·06 | 0·36 | 0·49 |
| | Per acre .. .. .. | 86 | 85 | 43 | 59 | — | — |
| 3 | Per tree .. .. .. .. | 4·91 | 2·33 | 2·35 | 1·83 | 0·63 | 0·87 |
| | Per acre .. .. .. | 275 | 130 | 132 | 103 | — | — |
| 4 | Per tree .. .. .. .. | 10·10 | 7·21 | 6·34 | 4·80 | 1·43 | 1·95 |
| | Per acre .. .. .. | 566 | 404 | 355 | 269 | — | — |

TABLE VI

MEAN YIELDS, LB. DRY SEED

| Age in years | Clones | | | | | | | | | | Sig. diff. per tree | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ZN24 | | ZM8 | | 14 | | ZF9 | | 10 | | | |
| | Per tree | Per acre | Per tree | Per acre | Per tree | Per acre | Per tree | Per acre | Per tree | Per acre | P=0·05 | P=0·01 |
| All plots: | | | | | | | | | | | | |
| 2 | 0·70 | 39 | 0·48 | 27 | 2·14 | 120 | 0·58 | 32 | 2·18 | 122 | 0·31 | 0·41 |
| 3 | 1·59 | 89 | 1·59 | 89 | 4·96 | 278 | 2·11 | 118 | 4·03 | 226 | 0·61 | 0·80 |
| 4 | 6·35 | 356 | 5·03 | 282 | 9·96 | 558 | 5·08 | 284 | 9·16 | 513 | 1·39 | 1·82 |
| Soya plots only: | | | | | | | | | | | | |
| 2 | 1·03 | 58 | 0·43 | 24 | 2·37 | 133 | 0·77 | 43 | 3·07 | 172 | — | — |
| 3 | 3·40 | 190 | 2·22 | 124 | 7·72 | 432 | 3·65 | 204 | 7·57 | 424 | — | — |
| 4 | 9·15 | 512 | 6·62 | 371 | 13·85 | 776 | 7·55 | 423 | 13·33 | 746 | 2·78 | 3·65 |

Yields have also been recorded from a number of plots of buddings at Kamponje Estate, by courtesy of the owner, Mr. L. J. Rumsey. Figures for these are shown in Table VII. The yields from the different clones are not strictly comparable as they are in the replicated trials described above, but clones in the same field may be regarded as being under very similar conditions and the yields as a whole are some indication of what may normally be expected from buddings as the plots have received no special treatment and the recorded trees are typical of the whole clone. It will be seen that the yields are better than those for the same clones in the trials at the experimental station described above. This is thought to be mainly due to the fact that whereas the clones at the station were planted as budded stumps in December, 1940, those at Kamponje were budded in October–November, 1940, on to seedlings aged 18 to 24 months which were already growing in the field. The latter, therefore had the advantage of an established and undisturbed root system and grew appreciably more vigorously than the station trees. It is probable that the decreased yields of the Kamponje clones in the third year indicates that they produced rather too much fruit for their strength in the second year, although it may be partly a seasonal effect.

no detailed study has yet been made of the variation in vigour and habit exhibited by a number of clones it is clear that the majority of clones belong to one or other of two quite distinct types. Type A grows vigorously, tends to make its first branches relatively high, and thereafter produces whorl after whorl of primary branches one above the other at fairly long intervals on the main trunk, resulting in a strong growing, erect and open type of tree. Type B is less vigorous, branches low and at very short intervals and has little tendency to increase in height, thus making low, dense, bushy trees. The latter type produces far more potential fruiting points in the early years than the former and is usually more precocious in bearing. It cannot yet be said which of these two types is likely to prove the more profitable. The early fruiting of type B and the rapidity with which it shades the ground and reduces weed growth are advantages, but the greater vigour of type A may easily mean that trees of this kind will prove superior in yield in the long run. Quite probably it will be found best to use a mixture of the two types, planting the type A trees at a relatively wide spacing and interplanting with the quicker cropping and smaller type B trees which can be cut out in due course as the type A trees mature and the land becomes crowded. There is considerable scope for this idea as some of the type B clones are particularly precocious in yield and remain dwarfish in vigour. Spacing experiments involving this method of planting are already in hand.

TABLE VII

MEAN YIELDS, LB. DRY SEED

| Field .. .. | A | | | B | | | C | | D | | | E | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clone .. .. | ZL22 | ZO23 | 14 | ZH14 | ZM8 | ZK3 | 4 | 10 | ZN23 | ZO8 | ZM13 | 14 | ZH14 |
| Number of trees.. | 20 | 19 | 20 | 10 | 19 | 13 | 20 | 20 | 7 | 9 | 12 | 83 | 28 |
| Two years .. | 4·0 | 5·1 | 7·8 | 2·9 | 2·4 | 2·8 | 2·6 | 4·5 | 5·5 | 8·6 | 9·6 | — | — |
| Three years .. | 2·9 | 4·0 | 4·6 | 2·2 | 2·4 | 5·8 | 1·8 | 1·3 | 3·6 | 7·8 | 4·1 | — | — |
| Four years .. | 10·3 | 11·6 | 16·0 | 14·3 | 12·4 | 22·4 | 7·5 | 12·4 | 11·8 | 14·6 | 21·5 | 22·5 | 17·2 |

In spite of the fact that budding has been done on seedling rootstocks, which must necessarily introduce some degree of variation amongst the resulting composite plants, certain characteristics of the mother trees are reproduced with remarkable uniformity in all the buddings derived from them, and there are well marked differences between clones in vigour, habit, flowering and fruiting. Although

It will be seen that only a small beginning has yet been made in the production of improved planting material by selection and

propagation as buddings. Only a few clones are yet in bearing and even these are only four years old. Nevertheless, the yield records already available clearly demonstrate the superiority of buddings to seedlings, and it will be seen that there are seven clones which have given from 12 to 22 lb. of dry seed per tree in their fourth year, or from three to six times as much as a good seedling plantation yielded at the same age (*see* Table I). It is considered that the use of budded material of this kind will raise the yield per acre to a level which would be profitable at pre-war oil prices, whereas it is very doubtful if seedlings would pay at those prices. Better yields than those given above are, however, expected in the near future, as amongst the more recently selected mother trees there are a number which are proving superior to those from which most of the early clones are derived. The question of improvement of rootstocks is also being investigated; the rooting of clonal material as cuttings, etc., is being attempted, and trials are being made with "selected" seedling stocks raised either from open pollinated seed from special trees or from artificial selfing of selected trees.

### Other Methods of Improvement

In 1940, when little or nothing was known of the possibilities of buddings, experiments were begun with two types of seedling material. In one trial plants raised from open pollinated seed of a number of trees are compared. No yields are yet available from these trees, but it is extremely unlikely that simple seed selection of this kind will be as effective as propagation by buddings, although the experiment may be of interest in connexion with the selection of seedling rootstocks. "Clonal seedlings" are also under trial. In 1941 three small isolated gardens were planted with buddings, two being monoclone blocks and one containing mixed buddings, with the object of finding out if by crossing between themselves these buddings would produce improved seed of any value. Seedlings from these plots are now planted out for trial, but again it is unlikely that they will be as good as buddings as they are bound to contain a proportion of predominantly male trees.

A much more promising line of work was begun in 1942 by artificially crossing and selfing selected trees with the object of producing a number of "legitimate seedling families" from which it is hoped later to produce improved planting material by vegetative propagation of the best individuals. Some hundreds of these seedlings have already been planted out, but none are yet in bearing.

### REFERENCES

[1] Webster, C. C.—A Note on the Yield of Tung Trees in Nyasaland. *E.A. Agric. Jour.*, VI, 160, Jan., 1941.

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One of the roots of the tree of peace is science. From root to crown there is a continuous flow of discovery, for modern civilization insistently demands new and improved forms of satisfaction and security. The creative powers of science can quickly make up some of the losses of war. We need new industries more than ever, more idle land put to use in new ways and old, more soil conservation, a scientifically determined balance between conflicting forms of land-use and water-use, better bodies and far better minds. Work and hope and sense and science and experience by and in our people will assist in the creation and application of these things.

Dr. Isiah Bowman.

## I.C.I. VALUES ACADEMIC RESEARCH WORK

Imperial Chemical Industries, Ltd., have recently endowed eighty fellowships at nine universities in Great Britain, to be held by senior workers in certain sciences. Lord McGowan, in his letter to the Chancellors of the Universities, wrote: "Nearly three generations of experience of the administration and conduct of research have convinced us that academic and industrial research are interdependent and complementary, and that it is useless to expect substantial advances in industry without corresponding advances in academic science".

# THE CARRYING CAPACITY OF PASTURES AT SERERE EXPERIMENT STATION

By R. K. Kerkham, Agricultural Officer, Uganda

*(Received for publication on 17th September, 1945)*

When problems of resettlement, overstocking and allied subjects are under consideration it is frequently desirable to know how many cattle the land will carry. Such a figure must of necessity have a very vague meaning; it will depend upon the type of cattle kept, whether additional food is used at times of grass shortage, whether the total number of cattle is increased or deceased at certain times of year by purchase or sale, and a number of other factors. It is believed, however, that experience gained at Serere during the past five years fill be of value to others concerned with similar problems.

The pasture work now being carried out at Serere follows up the work of Dr. Martin (1944), who has shown that the grass ley is an excellent method of maintaining soil fertility under Serere conditions. Comparisons of the fertility of land grazed during the resting period with ungrazed land is now the main item of experimental work, but the results of these trials will not be obtained for another year or two. A considerable amount of information on the carrying capacity of our pastures has been obtained during these investigations. The most valuable finding is that leys give more grazing than permanent grass.

## Situation and Climate

Serere farm is in Serere County of the Teso District of Uganda. The altitude rises from 3,550 ft. to 3,900 ft., nearly all the cultivated areas being on slopes of less than 5 per cent and below 3,700 ft.

Rainfall (Inches)

| Month | 1940 | 1941 | 1942 | 1943 | 1944 | Aver. 1921-44 |
|---|---|---|---|---|---|---|
| January | 2·02 | 1·01 | 2·15 | 0·44 | 0·12 | 0·82 |
| February | 6·58 | 2·12 | 1·77 | 3·57 | 2·89 | 2·48 |
| March | 4·55 | 2·87 | 5·93 | 1·13 | 2·07 | 3·63 |
| April | 8·31 | 12·62 | 10·22 | 6·01 | 7·30 | 8·10 |
| May | 6·97 | 6·10 | 13·96 | 7·74 | 7·40 | 7·07 |
| June | 3·06 | 4·83 | 0·75 | 5·74 | 4·44 | 4·40 |
| July | 7·62 | 3·27 | 4·25 | 2·09 | 3·29 | 4·55 |
| August | 6·15 | 4·67 | 10·76 | 6·74 | 6·14 | 6·31 |
| September | 2·90 | 4·90 | 4·49 | 2·51 | 8·46 | 5·87 |
| October | 2·24 | 3·95 | 1·41 | 2·40 | 5·44 | 4·35 |
| November | 6·07 | 8·58 | 1·15 | 0·25 | 7·14 | 3·90 |
| December | 0·87 | 3·93 | 0·53 | 0·56 | 3·63 | 2·10 |
| Total | 57·34 | 58·85 | 57·37 | 39·18 | 58·32 | 53·58 |

In spite of the relatively high rainfall this area is considered as part of the drier area of Uganda. The early rains are reliable, but the second rains erratic, periods of up to three or four months with negligible rainfall between October and February being by no means uncommon. During this period spells lasting several weeks, occasionally several months, with high winds, high temperatures (mean monthly maxima in January frequently exceed 95°F), and low humidities are usual. Presumably these conditions, combined with thin rather sandy soil, account for the fact that this area is much drier than other parts of Uganda which have a lower rainfall.

Underlying rocks belong to the Karagwe-Ankolean System.

## Types of Grazing on Serere Farm

The farm consists of two hills, Gola and Kakudoma, and their slopes. To the north the farm boundaries include the swamp verge, but elsewhere there is no wet land. Cultivation is carried out on strip cropping layouts on all sides of the hills, though considerable parts of the lower-lying land is unsuitable for cultivation owing to the thinness of the soil overlying ironstone. The main types of grazing are:—

(i) *Ley Grazing.*—The cropping system on nearly all parts of the farm consists of three years cropping followed by three years rest under grass. Grazing is started in the fourth year, i.e. first year of the ley, and continued until the land is ploughed up again. A number of grass mixtures have been tried, the most successful of which has been the local type of Rhodes grass, *Chloris gayana*, but a very good cover of *Cynodon* is obtained when land is allowed to regenerate without sowing seed, and little evidence has so far been obtained that sown grasses produce better grazing than natural regeneration. It must be borne in mind, however, that this refers to land which has been allowed to go back to grass whilst still in a fair state of fertility; results might be quite different if cultivation were continued beyond the third year.

These *Cynodon* pastures give very good grazing in the first and second years of the leys, but by the third year the *Cynodon* stand is frequently invaded by other less valuable grazing species, Spear grass (*Heteropogon con-*

*tortus*), *Imperata cylindrica* and *Sporobolus pyramidalis* being the most common. Attempts are being made to manage the pastures so that these undesirable species do not come in, but have not yet met with much success.

(ii) *Rough Grazing Lands.*—Considerable areas of the farm are now used for cultivation but not used regularly for grazing during the resting period. These come back to various ephemeral grasses in the first year, of which *Digitaria velutina* is the most common. In the second year *Imperata cylindrica* usually comes in and is followed by *Hyparrhenia rufa*. Such lands have occasionally been used for grazing in the dry season after burning. (Controlled early burning has been adopted as standard policy for this part of Uganda.)

About eighty acres of land were subjected to continuous cultivation from 1921 to 1934. Since 1935 part of this has been rested under grass and is used for grazing. Grass stands are very variable, poorer parts still contain much *Rhynchelytrum repens* and *Paspalum commersonii*, the better parts have been invaded by *Imperata*, *Hyparrhenia rufa* and *Cynodon plectostachyum*.

There is very little soil on the steeper slopes of Kakudoma Hill. The dominant grass species is *Loudetia arundinacea*. The hill is burned as soon as possible in August or September. Some useful grazing is obtained from four to eight weeks after the burn, but this species is unpalatable to stock during the remainder of the year.

(iii) *Permanent Pasture.*—A number of attempts to maintain land under permanent pasture have been made. *Chloris gayana*, *Brachiaria decumbens*, *Panicum maximum* and a number of other grasses have been sown for this purpose, but the final results have been very much the same in each case. The natural grasses mentioned above, in particular *Imperata*, *Hyparrhenia rufa* and *Sporobolus pyramidalis* eventually come in and crowd out the seeded species.

Of the 1,685 acres on the farm 790 acres have not been used for grazing since 1940. Of the 895 acres used for grazing 170 acres are ley grazing (85 acres grazed at any one time, the other 85 being cropped), about 170 acres were only used for grazing in the exceptionally severe dry season of 1943–44 and about 555 acres can be called rough grazing or permanent pasture.

### Cattle—Composition of the Herd

Cattle on the farm are all zebu. A few bullocks came originally from Usuku and have some Karamojan, Boran (?) blood, but the majority are of the small compact type met with throughout Teso and Mbale districts. The average liveweight of 24 adult bullocks slaughtered during 1943 and 1944 was 680 lb., and of 10 cows 586 lb. These bullocks were probably slightly beyond their prime, but the average maximum liveweight certainly does not exceed 750 lb.

The composition of the herd has remained fairly constant at about 150 bulls and bullocks, 60 to 70 cows and heifers, and about 40 calves. The amount of grazing by the small number of sheep and goats is negligible compared with the cattle, and need not be considered.

If the cattle population is taken as 250 throughout it will be near enough. The herd is now almost self-supporting, and is therefore roughly comparable with the type of figure obtained from a live stock census in native areas, though the proportion of males is much higher than in most parts of Uganda now.

### Supplementary Feeding

All cattle have been fed and watered within the farm boundaries since 1940.

The only supplementary feeds given are cotton seed and sorghum silage. The average amount of cotton seed bought per year is 20 tons, and the average amount of silage made about 80 tons. Supplementary food is given to milk cows and working bullocks from the onset of dry weather in October or November until March. As a matter of interest it may be worth noting that the amount of cotton seed produced on the farm is about 15 tons per year, so slightly more is bought than is produced. All cattle are given salt.

### Management of Pastures

All major grazing areas are allocated a fixed herd of cattle, i.e. numbers are not varied from time to time. It is realized that this is not an ideal system of management, but the African farmer is not in a position to increase or decrease his herd in accordance with the amount of grazing available. In dry years it has sometimes been necessary to remove cattle from certain areas in order to prevent permanent damage to the grass cover. Sufficient additional grazing is available to allow this to be done, but any system which requires such supplementary grazing is considered unsatisfactory.

During the past two years a weighbridge has been used. Before this was obtained cattle were removed when they began to lose condition; the weighbridge has proved a useful check on visual impressions. Under the better

systems of management cattle between the ages of one and five years of age gain between 150 and 250 lb. per year. The gain is highest in March and April, but no appreciable drop in weight in the dry season occurs under good systems.

Apart from certain areas which are grazed continuously for experimental reasons all pastures are grazed under some form of rotational, or deferred rotational, system of management. Insufficient data have as yet been obtained to form an opinion as to which of the various methods of grazing tried is best.

### Carrying Capacity

(*a*) *Overall Capacity.*

As shown above 250 head of cattle are kept on approximately 900 acres of land, i.e. about $3\frac{1}{2}$ acres are used per beast.

(*b*) *Ley Grazing.*

Of the 60 acres of the experiment farm, where a ley system has been used since 1934, 20 acres are always available for grazing. This farm has carried 20 adult cattle since 1940 without supplementary feeding, and these cattle have given higher liveweight gains than cattle kept elsewhere. They stay on this farm day and night except when they go out for work. In the 1943–44 dry season it was necessary, however, to allow them access to additional grazing for two months.

Fourteen adult bullocks have been kept on 36 acres of land on Main Farm (West) since May, 1941. Eighteen acres are cultivated each year and between 12 and 18 are available for grazing. These bullocks graze during the day, when not at work, but sleep in a kraal and receive standard supplementary feeds. Ample grazing has been available at all times including the 1943–44 dry season.

Fourteen adult bullocks have been kept on 41 acres on the Training Farm since May, 1941. Nineteen acres are cultivated each year and about the same area is available for grazing. This farm was allotted an additional area of wettish land for dry season grazing, but it has not been necessary to use it in 1943 or 1944. These bullocks receive standard supplementary food. They sleep in a kraal.

Twenty adult bullocks have grazed on 33 acres of land on Main Farm A (East and Central) since January, 1941. Not more than $16\frac{1}{2}$ acres are ever available for grazing. These bullocks sleep in the kraal at night, receive supplementary feeds and are tethered on the grass strips by day. In the 1942–43 and 1943–44 dry seasons it was necessary to allow them access to additional grazing; in 1941–42 and 1944–45 (both wet years) grazing was sufficient.

To summarize this section, experience here indicates that resting leys of the type described will carry a beast to the acre in a good year without supplementary feeding. In the exceptionally dry year 1943–44 some extra grazing was required with this stocking rate. When given supplementary food in the dry season stocking rates of slightly more than a beast to the acre are possible.

(*c*) *Rough Grazing Lands and Permanent Pasture.*

Approximately 180 head of cattle are run on the 555 acres of rough grazing or permanent pasture. All these cattle are given supplementary feeding. On one permanent pasture on the Old Farm, Block 3, which was in a fair state of fertility, an attempt was made to keep two bullocks on three acres from 1941 to 1944. Supplementary food was given when necessary, but even then it was necessary to remove the cattle in the 1943–44 dry season. On three ten-acre paddocks of rather poorer land on the Old Farm an average of 18 young cattle have been kept since 1941. In spite of supplementary feeding liveweight gains have been on the whole poor. An attempt was made in 1941 to keep four bullocks on five acres of permanent pasture. This was sufficient until 1943, but it was then necessary to open a new paddock owing to *Sporobolus* invasion. These bullocks received supplementary food in the dry season.

To summarize this section, stocking rates on permanent grazing lands of more than one beast to two acres have not been successful.

### Acknowledgments

The pasture work now being carried out by this department at Serere follows up work done by Dr. Martin (1944) and his collaborators. Suggestions and advice have been received from many members of the department, and members of the Veterinary Department. Messrs. A. L. Stephens, W. J. Badcock, T. McEwen, T. R. Hayes and Dr. W. S. Martin have perhaps been most frequently consulted. I am indebted to Dr. Rowlands of the South African Pasture Research Division for much advice and assistance whilst I was in South Africa in 1940. Mr. S. M. N. Kijambu, Assistant Agricultural Officer, has been responsible for day to day supervision of paddocks since 1942. All work with grasses and pastures in Uganda benefits from the systematic collections of grasses made by Messrs. A. S. Thomas, A. L. Stephens and P. Chandler. Botanical names in this paper have been taken from Dr. Eggeling's "Check List of Uganda Grasses".

# GOATS, FIRE AND BLOWING SANDS

By Colin Maher, Soil Conservation Service, Kenya

In December, 1942, the Governor-General of the Sudan appointed a Soil Conservation Committee with the following terms of reference:—

(*a*) To report on the present situation in the Sudan with regard to soil erosion and desiccation and the availability of rural water supplies for the human and animal population.

(*b*) To make recommendations in respect of any of the above matters and of any measures of legislation or taxation which may be required for the carrying out of such recommendations.

(*c*) To draw up a programme of work covering a stated period of years for the implementation of the recommendations.

(*d*) To provide estimates for the capital cost of carrying out the programme and of the future maintenance costs involved.

The Chairman of the Committee, which consisted of five senior officials, was Dr. J. D. Tothill, well known to East Africans, who is now Principal of the Gordon College, Khartoum.

The Committee met on fourteen occasions and considered a mass of evidence and a number of memoranda written by members of the Committee and others.

The report of the Committee, an indexed volume of 174 pages, in cloth board, was received in East Africa recently. This report contains a great deal of interest to those concerned with the technical, economic and social problems connected with the protection of natural resources in East Africa.

From the point of view of the outsider, unfamiliar with the Sudan, the material would have been easier to study if it had been presented in a more closely collated form, showing the situation in a more connected way. However, as this Report was primarily intended for use inside the Sudan perhaps this is not entirely a valid criticism and the index indeed compensates (in some part) for this difficulty.

First of all a chapter is devoted to the archaeological evidence in East Africa and the Nile Basin which appears to indicate that there has been no major change in climate for the past 3,000 or 4,000 years, or since the latter end of Neolithic times; thus any deterioration in the soil and vegetation must be attributed to the action of man—"civilized man"—and his stock rather than to any progressively unfavourable conditions. There follows a chapter giving recommendations on broad lines for action, province by province, in specified areas and a chapter listing the projects—a truly American conservationists' word!—which are recommended to be carried out on the instructions of a Soil Conservation Board to be formed under the Chairmanship of the Director of Agriculture and Forests and to include the Financial Secretary, Civil Secretary, Chief Conservator of Forests, Director of Veterinary Services, and Government Geologist.

Part II consists of extracts from the minutes of meetings at which the principal recommendations were made, and Part III a series of Appendices which are, for the most part, papers written on particular agricultural, ecological, geological, historical or other aspects of the erosion problem in the Sudan. The index in Part IV thoughtfully includes a glossary of those Arabic terms which would otherwise mystify the uninitiated. This might, however, have been amplified with advantage. Included in the report are a political map of the country and one showing the distribution of population.

The Sudan has a rainfall which varies from almost nil in the northern desert region to over 40 inches in south-western Equatoria, which adjoins the Belgian Congo and French Equatorial Africa. The rains fall heavily during a short season and there follows a long dry season with a high temperature and high evaporation and transpiration rate. Under these conditions surface water and subsoil water at shallow depths is exhausted rapidly. During the grazing period in the north-west of Kordofan the camels require no water for six months—and as no water supplies are available the herds live on camels' milk alone. A large part of the Sudan is a plain with gentle slopes, broken by steep-sided hills and mountains. Some of these are in ranges such as the Imatongs and the Delami-Heiban-Talodi hills in south Kordofan; others are isolated small inselbergs in the plains. Run-off is rapid from the hills, some of which are composed of relatively impervious crystalline rocks, but the gentle slopes of the plains, with a low rainfall, give a slow run-off. Some of the lower hills are sandstones which readily absorb water and hold it deeply in reserve.

In the plains there is a thick cover of superficial deposits, consisting of sands, clayey

gravelly sands, sandy clays and heavy cracking clays (so-called "cotton-soil"). The pervious sands absorb water readily but little water passes to the soil through the heavy impervious clays and the rainfall gives no underground supply.

The population is densest, as might be expected round the Nile and Blue Nile with the largest town—Khartoum—at their junction and Wad Medani, the capital of the Blue Nile Province, on the river of that name, 109 miles above Khartoum. Another large population centre is El Obeid, capital of Kordofan Province, whence the gum arabic supplies are chiefly derived.

The southern area, including the Province of Equatoria and the Province of Upper Nile (away from the river itself) is sparsely populated with under five people per square mile. There is a similar population density in the northern halves of Darfur, to the west of Kordofan in central Sudan, together with the Northern Province and most of Kassala, adjoining the Red Sea, except for the riverine strips which have a population of 50 to 250 to the square mile. The central and southern portions of Darfur and Kordofan and part of the Blue Nile Province have populations of between 5 and 50 to the square mile.

Naturally, with the rainfall and climate concerned, the areas of permanent settlement which are away from permanent water supplies are dependent on underground supplies. These, however, are not always found, even at considerable depths. Some groups are dependent on surface or shallow water supplies which are impermanent, thus forcing the people to migrate. It is evident from this Report that the nomads of the Sudan are considerable thorns in the side of Government and of the settled populations. The Director of Veterinary Services, Lt.-Col. C. P. Fisher, observes "Nomads are not nomads from choice, they are so because they must, and for this reason must be accepted as they are. Communal land tenure is the only workable system for them, and with this system nobody can introduce improvement in advance of the slow sense of the mass of his fellows. It should be the aim of Government to translate pastorals into agriculturists wherever it is possible, for the limit of progress with pastorals has long since been reached and their animal problems can be summed up in the one word—food. Some change in the native system of land tenure of nomads is regarded by many as the first logical step towards improving the lot of the native and preserving his land for future generations". An alternative perhaps would be some form of collective tenure of certain grazing lands, coupled with the provision of additional water supplies, such as has been developed and operated successfully by ranchers in Montana.

On the other hand the concentration of population in towns and villages produces its own difficulties which will be described later. The northern part of the Sudan consists of arid desert, irreclaimable by man. The greater part of the country, however, consists of savannah bush in which a human population can only maintain itself in a condition of unstable equilibrium with the vegetation. This is a state which pertains also to large areas in other parts of Africa including East Africa. The balance may easily be disturbed by overstocking, over-cultivation, over-population or by careless use of fire so that the vegetation deteriorates, possibly irreversibly, and man is driven out of the area by the effects of his own destructiveness.

G. M. Hancock in an article on the grass-acacia cycle in the Blue Nile Province south of Sennar gives the vegetation of the river basins as consisting largely of *Acacia arabica* and *Ziziphus* sp. On the sloping river bank, north of lat. 13° there are prevalent *Balanites aegyptiaca*, and *Acacia nubica* with some *Acacia seyal* and *Acacia mellifera*. Dom (*Hyphaene*) and Baobab occur south of this with deciduous patches on the sandier soils. The dominant grass along the riverine strip is an aromatic *Cymbopogon* which is disliked by grazing animals. On the clay plains Acacia forest and savannah are distributed irregularly in patches of varying size. The forest consists mainly of *Balanites aegyptiaca*, *Acacia seyal*, *Acacia mellifera* and *Acacia senegal* (syn. *A. verek*). On the west bank *A. mellifera* is more prevalent, occurring in pure stands north of lat. 13°.

The savannah consists of mixed grasses up to 6 ft. or more in height of which the commonest are *Cymbopogon* sp., *Sorghum* sp. ("Anis"), and *Rottboellia exaltata*, all of which occur in extensive and almost pure stands, and another *Sorghum* sp. ("Addar") and also "Ansora". Between the Blue and White Niles especially north of lat. 13° the savannah is very extensive and in places completely devoid of trees and in others sparsely dotted with acacias and *Cadaba* spp.

Following this introduction various matters dealt with in this Report may be considered in detail, especially where the problems have their analogues in East Africa.

*Overstocking.*—According to the Director of Veterinary Services, although stock numbers are not known, there is an *estimated* population in the Sudan of 3,000,000 cattle, 6,000,000 sheep, 5,000,000 goats and 1,000,000 camels. He points out that for reasons of climate the Sudan is predominantly pastoral and must remain so for generations, if not indefinitely. He states that "Almost the entire cattle population is owned by pastorals who are forced by the uneven distribution and seasonal incidence of the annual rainfall to be nomadic. In the north, watering centres in the dry season are few, and the grazing areas in the immediate vicinity are always overstocked; they will always be so, no matter what the animal population may be, the belt of denudation varying in direct proportion to the numbers".

The use of vaccines for rinderpest, contagious bovine pleuro-pneumonia, anthrax and other diseases has undoubtedly led to an increase of the cattle population. Lt.-Col. Fisher suggests that the Soil Conservation Committee might make recommendations to Government with a view to reducing the stock population by, for example, the withholding of rinderpest prophylactics.

In the Sudan as in East Africa the pastoralist relies on keeping enough stock to allow of a weeding out of the less fit—less fit for survival—by dry season starvation. Lt.-Col. Fisher adds "The nomads method of holding as much stock as possible may be sounder in practice than it appears. Certain it is that so long as he remains a nomad he will never voluntarily restrict his breeding, for if he does, others won't, and where grazing is communal, he stands to lose. *It would seem that before anything can be done with a nomad he must be translated into something else.*

"The difficulty in estimating the stock-carrying capacity of any particular area is the great variability of the rainfall which makes it impossible to lay down a fixed figure; the bad season sooner or later turns up. To estimate capacity on the bad season—which is the real capacity—is to forego the bounty of the good". He notes that "The Committee is not asked to make any recommendations for the forced limitation of stock held by pastorals as such. If soil erosion is occurring in their areas due to overstocking it is considered that the problem should be met by providing an economic outlet for the surplus such as the war demand is now doing in the case of cattle, sheep and camels. 50,000 cattle a year are being exported as against 8–10,000 before the war". 100,000 camels were taken to Egypt each year during the war.

The war is now over, with its temporary easing of the live stock situation. There are three types of tax on stock including animal tax under the Taxation of Animals Ordinance; Tribute, which is a combined tax based on animal holdings and annual crops of a whole tribe or local administration; and Poll Tax which is a flat rate tax based on animal, crop and other resources, and is assessed annually. It is considered that increase in Poll Tax and Tribute rates would be met by means other than the sale of animals. The herd tax is not considered a suitable tax to stiffen in order to bring about stock limitation since there are great difficulties in assessing the tax accurately amongst nomad communities.

Eventually the Committee, rejecting the proposal of a new stock tax, discriminatory in nature, as a means of inducing stock limitation, accepted Dr. Tothill's proposal of the provision of a free cattle health service which should be provided by the Veterinary Services in return for the poorest males (somewhat redundantly described in one place as 'male bulls'!) culled out each year to the number required to keep the stock numbers constant.

No mention is made of the culling of scrub cows except possibly "at a later date" depending on whether the stock improvement scheme meets "with general approval", and it remains to be seen whether the proposed system will prove entirely adequate. It would seem likely that there may be some difficulty in obtaining individual contributions of scrub stock in return for the general veterinary health service. As mentioned earlier some development of communal tenure and grazing associations with fixed rules and obligations seems desirable though doubtless exceedingly difficult to inaugurate amongst custom-ridden ignorant nomads.

*Goats.*—Experience with five million goats should be enlightening and perhaps might be taken advantage of by the more recent capriphiles of East Africa. Sudan takes the goat question quite seriously as is shown by these animals being cross-referenced 24 times, more times than any other subject, in the index of this Report.

The Director of Veterinary Services comments somewhat plaintively "Wherever any domestic animal can live, the goat will thrive. He is a browser as well as a grazer and can exist on anything that is not absolute desert. There are three types: (1) Nubian, (2) Desert,

(3) Nilotic. Goats suffer from few epidemic diseases and there seems to be no means of limiting their numbers short of forced slaughter, for they are unexportable and cannot be taxed out of existence. As with other domesticated animals it is impossible to lay down how many the nomad requires; again the answer seems to be to settle the native wherever the land is good enough, and whereever not, he must be left alone. The goat population has been estimated very roughly at 5,000,000. No goats are exported".

Goats are reported, together with camels, to be turning into desert the perimeters of the large towns—a question upon which more will be said later. The camel and the goat are said to have been responsible almost entirely for "the increasing momentum in erosion" especially at Erkowit, while in the Blue Nile Province in some of the bigger settlements "the density of the local goat population, following an exhaustive cropping, prevents the growth of any vegetation at all". These same animals are responsible for the evil conditions in the large towns. "Most of the moving dust blown in winter can be shown to be started by the outward passage of Khartoum North flocks of goats. An evening cloud similarly accompanies the herds into Omdurman where the wind is slightly west. The Deims and Khartoum suffer similarly from May onwards. . . .".

"The milk from town animals is drawn from goats which can be photographed licking tyre-worn patches of horse and donkey dung off tar-macadam roads. The Khartoum goats regularly walk over the Jebel Bouser refuse dump for rags and toilet paper. The goat-created circle of desiccation surrounding the town is best appreciated from the air. The diets already described are the best evidence that the grazing assets are gone and that conditions exist (which could be removed) which prevent their re-establishment".

However, in 1939, the Civil Secretary deprecated discriminatory taxation against goats while the Medical Department were in general opposed to measures likely to reduce the poor man's supply of goat milk. No proposals appear to have been made by the Sudan Soil Conservation Committee, like many an official body before it, to deal with the goat question except in limited areas such as town perimeters which will be described separately. Probably there is no solution anywhere other than resettlement and an improvement of living conditions and agricultural possibilities for African populations.

### Town Perimeter Protection

There has been some deterioration of the outskirts of Nairobi, Kisumu and Kampala, and probably of other East African towns, caused by the African population living in and around the towns. However, the damage which has been done pales into insignificance before the state of the land in and around the towns of the Sudan in a semi-arid climate. The officials who narrate the tale of the condition of the land in and around these towns write with an apparent bitterness which pierces through customary official dispassionateness. We have heard of the discomforts suffered in the dust-ridden towns of the Sudan; probably these officials are troubled not only by sand in their soup but by a disquieting doubt as to the unsavoury origin of the sand.

The discussion of measures to be taken to remedy the deplorable situation which exists in the perimeter of the larger towns must have taken up a considerable part of the time of the Committee. The "perimeter" is defined as "a band of land two to eight miles wide measured outward from the houses surrounding a village or town and within grazing range of town animals. Alternatively all land within the outer limit of that band, including the town itself."

Most of the damage is due to the destruction of all vegetative cover by grazing animals, especially due to the custom of keeping milk animals within the towns, a custom which is forbidden in East African towns though the law in the matter is frequently flouted by Somalis.

Traffic and overgrazing has resulted in the sand of Tuti Island near Khartoum being "carried across the Blue Nile as well as into it" so that it threatens to close the present channel.

The action of goats has already been mentioned. Deforestation for fuel has also contributed to the state of deterioration. Conditions are particularly bad near Tokar on the delta of the Baraka river on the Red Sea. Here the average annual rainfall is only $3\frac{1}{2}$ inches. Originally the delta was well wooded till the trees were cleared in 1860 by Mumtaz Pasha, Governor-General of the Sudan, in order to grow cotton. From June to September the strong Haboob or dust wind blows down the Baraka valley from the south-west and often carries dust miles out to sea. This wind forms great sand dunes half of one of which was recently cleared from the south-west side of Tokar at a cost of £40,000. Three tiers of houses were found, one on top of the other,

when the sand was cleared. A deposit of sand up to five or six feet deep and extending over two hundred yards or more up the sides of the street was left by the Haboob wind each year until exceptional rains in 1940 and 1941 enabled a growth of *Suaeda fruticosa*, afterwards protected, to establish itself outside the town. This vegetation since this time has filtered out most of the dust. The "hababai" wind which blows from the east is also a violent sand-laden wind which blows from the middle of September till December. This works counter to the "haboob" to some extent but it "will gouge out a quarter of a mile square and more of growing cotton and up to four feet of depth of earth with it. Nothing is growing during the Haboob season but it scours the earth to a far greater depth".

The Committee agreed that the town perimeters of Omdurman, Khartoum North and Khartoum were out of control and also agreed with the recommendations regarding Atbara and Tokar.

Dr. Tothill had pointed out that "the land poverty in Upper Nile largely results from the overworking and overgrazing of village perimeter lands". He added "It begins to look as if not every town, but every village in the country should now be developed according to a plan".

The question of the planning of village settlements will be the subject of a separate paragraph. Meanwhile it should be remembered that the development of villages in East Africa is necessary if water supplies, health, recreational and educational facilities are to be provided, and agricultural and pastoral development to be carried out on proper lines. Special attention should, therefore, be paid to the recommendations of the Sudan Soil Conservation Committee regarding the protection of town and village areas, the lining of streets by trees and the growing of one tree in his yard by every householder; the limitation or prohibition of goat keeping within town areas; the provision of fodder supplies, on payment, from irrigated land outside the towns for milk goats, sheep and donkeys, the grazing of which is prohibited within the towns; the provision of wood feul from outside town perimeters. It was decided that the rights of citizens should not be deemed to include the right to graze within towns. Access to approved grazing areas should be by authorized routes planned with a view to avoiding nuisance from dust. In some areas experiments with growing mesquite for fuel were to be tried. Vetoes were to be strictly enforced on cultivation within township boundaries and main streets to be hard surfaced.

### Village Planning

A memorandum on "Village Lay-out in Rural Areas" by G. M. Hancock is very reminiscent of proposals which have been made for reorganizing the agricultural and social system in the Machakos and other Reserves in Kenya Colony. This memorandum should be studied by officers concerned with development plans in East Africa.

"The lay-out must provide for:—

(*a*) Sufficient land to allow for three ten-year rotations, one under cultivation, one under protection and regeneration and one under grown timber for grazing and supplying fuel and timber.

(*b*) Adequate and convenient water supplies.

(*c*) Market enclosures, shops, schools, dispensaries, public health facilities, mosque and central hall (or court house) on a scale commensurate with the standard of expenditure which the Government is willing to approve. This expenditure should be generous as those experimental settlements will be centres of progress and enlightenment and will be models which it is hoped that the neighbouring villages will copy."

It is suggested tentatively that a suitable new territorial division would contain sixteen villages of about a hundred households each, grouped round a central village or small town containing the amenities shown above.

### The Grass-Acacia Succession

A large part of the agricultural land of the Sudan including the clay plains of the Blue Nile Province is cultivated on the "harig" system. This is a form of shifting cultivation in which the land is not cultivated for more than two years in succession. The dead grass of the previous season is burnt off, so destroying seedling weeds. When cultivation is relinquished the grasses return and *Acacia* spp. enter later. The operation of the cycle depends on whether grass is retarded by bad rains or locust attack, so that the country is free from fires which destroy the young trees, or whether the soil is removed by erosion. Acacias regenerate more rapidly under shifting cultivation than under the more exhaustive methods which are used around the permanent settlements where goats, also, take a heavy toll of

the tree growth. Fires are inimical to the growth of acacias.

Hancock suggests an ordered rotation in the river valleys of the Blue Nile Province. A typical village of 100 cultivators would be allotted about five square miles which would be divided into three blocks. For the first six years a block would be cultivated, then the area would be allowed to return to grass and trees would be allowed to renegerate, grazing by cattle and sheep being permitted but not by camels and goats. In the third period the block would be grazed by all classes of stock and timber and fuel supplies could be obtained from the block. In the second stage of the rotation fire lines protected by paid fire guards would be necessary.

As in East Africa the storage of fodder harvested during the period of plenty is needed as a necessary part of the improvement of pastoral husbandry in the Sudan.

### Fire

In East Africa, although there are laws for controlling or preventing grass burning, there has been a considerable amount of difference of opinion, in and outside official circles, as to whether burning is, if not a blessing entirely, a necessary evil in the management of certain types of pasturage. The members of the Sudan Soil Conservation Committee and their consultants were in no two minds on the matter. In their own words "At the present time most of the country is annually swept by fire and over great areas serious damage is done in the destruction of regenerating forest and of the soil itself and we regard these annual fires as a contributory cause of erosion".

There are a number of causes of fire in the Sudan. As in East Africa the grass is sometimes burnt for cultivation in order to obtain fresh grazing; but it is also burnt by villagers in malice to prevent nomads from making use of grazing near the villages and by Arabs on the march to avoid the danger of following fires. Honey hunters and hunters of game provide their quota of damage by fire as they do in East Africa. The check caused by fire to the Grass-Acacia sequence has been mentioned. Damage is also caused to forests. In the Red Sea hills fifty years ago the tops of the hills above 6,500 ft. were covered with forest, mostly a juniper. Since then destruction of large juniper trees over large areas and the prevention of natural regeneration has caused a rapid run-off, erosion and deterioration which has led to *Dodonaea viscosa* replacing the juniper, and in some places the slopes have become too dry even for *Dodonaea*. The fires were probably started to kill out weeds and juniper which were useless for goat fodder and to make a large area available for increasing herds and flocks.

The deterioration in cover which is described is very reminiscent of the disappearing forests of Kenya cedar (*Juniperus procera*) on the Laikipia plains and on the hilly slopes of the Leroghi Plateau adjoining the Samburu Reserve in Kenya. Undoubtedly grass fires in both these areas have killed large trees and young growth while the open nature of the patches of forest growing under marginal conditions on the edge of semi-arid country no longer affords suitable conditions for natural regeneration.

The Committee advised early burning in some areas, such as part of the Equatoria Province in the Nile Congo area, where complete protection cannot be afforded. The general view appears to be, however, that where natural regeneration is progressing favourably, complete protection should be given as soon as possible.

In the Blue Nile Province in "harig" and gum areas, as well as in Equatoria, a grid system of fire lines is proposed as a long-term measure to limit the spread. In the Nuba Mountains experiments are proposed to test the efficacy of earth banks and bands of various kinds of vegetation as firebreaks.

The Chief Conservator of Forests in the Sudan is particularly perturbed in regard to the destructive effect of fires. East Africans should search their hearts when he says "a first step everywhere is to drag ourselves out of the mental condition in which we have come to accept fires as inevitable and the problem as insoluble. There is only one condition under which the burning of old grasses to encourage new can be justified botanically and that is on low-lying toiches and true swamps. Under no conditions should annual grasses be burned".

### The Protection of Valley Heads

The African is notoriously fond, whether he is a Kikuyu "squatter" in the Kenya highlands, or a Bantu Kavirondo, of cultivating his crops in river valleys and around the sources of streams. The humus derived from riverine forest and the dampness of the soil in the dry weather afford excellent conditions—for a time—while the digging of a steep slope, pulling downhill, is rendered an easier task through the assistance of gravity.

In Equatoria Province forest watersheds are deteriorating through agricultural development in the valleys. The Committee proposed that these areas should be permanently preserved as forest reserves, being delimited, marked and protected with fire lines.

### Forestry

The Forest Reserves of the Sudan, excluding the desert area, represent only 0.76 per cent of the rainfall area. The Chief Conservator of Forests justly regards this as quite inadequate compared with the figures which he quotes for other countries, viz:—

Great Britain: 5.6 per cent.
Finland: 73 per cent.
Belgium, France, Greece, Italy: approximately 17 per cent each.
India: 10 per cent.
Burma: 13 per cent.
Cyprus: 17 per cent.
Kenya: 2.4 per cent.
Nigeria 5.45 per cent.
Tanganyika: 1.18 per cent.
Uganda: 2.54 per cent.

The Forest Reserves of the Sudan total 3,762 square miles. An important part of the activities of the Forest Department is the safeguarding of desert scrub, in the vicinities of the towns, the destruction of which leads to increasing trouble from dust storms within the urban areas.

### Rural Water Supplies

In the words of G. M. Hancock "in general, our aim should be to improve social, educational, agricultural and public health conditions in rural communities, and any schemes for such improvement must be based in the first instance on local water supplies". This is definitely the case in East Africa also; but in the latter territories there appears to be inadequate official appreciation of the fact that water supplies can only be provided economically for concentrated village settlements and that a social system in which individual huts are scattered all over the country side is not only prejudicial to the organization of an efficient technique of agriculture and pasture management but to the provision of necessary educational and public health facilities—and a good water supply ranks high in the latter category.

The order of importance and desirability in regard to purity of supply, adequacy of supply and freedom from disease is placed as (*a*) deep wells, (*b*) river water, (*c*) canals, and (*d*) village hafirs or ponds—"one of the most insanitary sources of water supply known", (*e*) rock pools and baobab trees.

The Committee recommended an executive organization to work on behalf of the proposed Soil Conservation Board, chiefly in providing rural water supplies, as follows:—

"1. Geological advice on type of supply best suited to the locality where water may be required.

2. Exploration work by drilling units where geological conditions may be uncertain.

3. Maintenance of a central school of well-digging ostas [skilled workmen] and key men to enable units of these people to be loaned in rotation to Governors to execute well-digging programmes approved by the Board. The labour for digging would be recruited locally.

4. Operation of a number of drilling units for the provision of the comparatively shallow bores to be fitted with hand pumps.

5. Maintenance service for completed installations.

6. Operation of units for providing water from depths down to 700 ft."

The organization consisted of a Geological Survey Head Office, and a Drilling Section to drill 40 wells per year for five years at an estimated capital and recurrent cost of £E 188,550. This was in addition to five-year provincial plans for the betterment of rural water supplies to be submitted by Governors for the approval of the Soil Conservation Board.

### Social and Economic

Soil erosion is the tragic end of the trilogy of Ignorance, Need and Greed. Sands will blow and rivers run with mud or become choked with silt if all three factors are not dealt with. This report has surprisingly little reference to human trends in the Sudan. There is little or no mention of population pressure except on the eroding lands upon the Blue Nile between Sennar and Roseires. The estimated male population of 40,000 in this area is considered by Hancock to be twice too much.

It appears that if water supplies are provided there is available land for new settlements, the organization of which is to be fully planned. G. M. Hancock's memoranda on the planning of villages has already been referred to. There is only one reference to "Social Planning"—a brief paragraph by the same author in which he suggests that if new settlements are made in the Blue Nile Province "a fine opportunity

would be provided for establishing planned social units in the newly settled areas on lines which allow for educational, medical and agricultural advances in the best possible manner". He mentions the desirability of improving local rural centres "to a standard far above their present low level . . ." to attract population away from the towns and reduce the present deplorable urbanization of a naturally agricultural and pastoral community".

There is no mention of the word poverty nor any indication of the living standards enjoyed by the indigenous inhabitants of the Sudan. There is no discussion of the question of the nutritional requirements of the local peoples except that some concern is experienced regarding the supply of goats' milk for the poorer people in the towns.

The question of the stabilization of the nomad communities is an important one both from the point of view of protecting soil and water and in order to obtain proper management of the pastoral areas. There is no indication, however, of the extent of this problem nor, it seems, any suggestion as to how this difficult matter can be dealt with.

In general it appears, however, that the Sudan has no such urgent sociological problems as are facing, for example, Kenya Colony with a number of over-populated and deteriorating reserves, which cannot continue to carry their present populations without proceeding to complete ruination; and Kenya Colony must be considered to have very scanty resources in the way of alternative settlement areas for surplus peoples.

### Conclusion

The Report which has been reviewed contains a great deal of valuable ecological, geological and other information which is very relevant to East African problems. As has been mentioned above too little attention seems to have been given to the basic social causes of deterioration of the land. Nevertheless a number of important recommendations have been made including suggestions for work to be done and that a Central Soil Conservation Board should be inaugurated. The ball is presumably now with the Sudan Government; but social and land planning is apt to end ingloriously with the appointment of committees, commissions and boards and the publication of reports as we in East Africa know. The jibe that "soil conservation" is "soil conversation" is now too stale to raise anything but a forced smile—but in the past it has had too much truth for palatability. *The Economist* at the end of July remarked "To undertake detailed and expert research, to appoint several able and authoritative committees, and then to do nothing, is a common pattern in English public life and nowhere more so than in the field of land use and town planning". The Sudan Government has a high reputation; it can afford to be "un-English" in this regard!

The Committee when dealing with the question of the provision of water supplies and the necessary executive body was on solid ground, and it may be presumed that its recommendations were adequate to the needs of the situation. Much of the work which is necessary in other directions will doubtless fall to be carried out by technical departments such as the Forest Department and to provincial and local authorities.

It seems, however, that apart from staff appointed for the provision of water supplies, the field staff to act as field representatives, or liaison officers of the Soil Conservation Board, as advisers on soil conservation problems and, at times, supervisors of special tasks connected with the protection of soil, water and vegetation appears to the outsider to be inadequate for work in a huge territory such as the Sudan.

A Soil Conservation Section is suggested, consisting of two soil conservation officers, one draughtsman and one clerk. When we read that £E 40,000 was spent recently on removing half a sand dune which was invading the town of Tokar, it does not seem that the provision of staff to advise upon and stimulate work designed to avoid such large remedial expenditure was regarded with due seriousness. No detail is given in the Report as to the functions which are proposed for this small staff. The comments of Dr. Hugh Hammond Bennett, father of modern soil conservation, may be quoted from his recent report on "Soil Erosion and Land Use in South Africa". "An engineer is not necessarily a soil conservationist. Neither is an agronomist, nor a forester. Soil conservation calls for the techniques of the crop specialist, the live stock specialist, engineers, foresters, soil scientists, and other specialists—all working together as a single co-ordinated whole. That is soil conservation".

It would seem that the Sudan has prepared a plan of action, appointed a general staff, but has maintained the British tradition in the Sudan of "a thin red line of heroes" to oppose —not this time the hordes of the Mullah—the inexorable sand dunes of the desert.

# GROWTH RATES OF HAIR ON GRADE EUROPEAN AND INDIGENOUS BREEDS OF CATTLE

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory

(*Received for publication on* 30*th November*, 1944)

During the past few years much has been written on the inability of pure- and high-bred European cattle to thrive continuously under tropical conditions; and by "tropical conditions" is not meant merely those of residence in areas within the tropics because altitude can produce a variety of non-tropical climates even on the equator itself. As a result of this work, it is now recognized that one of the main factors involved is the inability of European animals to eliminate heat sufficiently rapidly to maintain normal body temperatures.

European stock are larger than local indigenous cattle and consequently need more food, the metabolism of which liberates energy in excess of that which has to be eliminated by indigenous stock. Thus, in spite of being less efficient at heat elimination than Zebu cattle, European grades and pure-breds also have to deal with greater quantities of heat. Further, the slight fever to which these imported types are subjected has an enervating effect which diminishes appetite and the animals often eat less food than they require. This results in slow growth and reproduction and the animals become tucked up and unthrifty.

Attention has naturally been focused upon the factors involved in heat elimination and the longer-haired coat of the European types in one factor incriminated. By enmeshing a layer of air close to the body, a long-haired coat slows down the rate at which heat can be dissipated by radiation. Recent work in South Africa [1] has shown that the colour of the coat and the length of the hair are also involved in the amount of heat absorbed from the sun. Moreover, the proportion of incident sunlight reflected from cattle is influenced by the colour and length of the hair. The invisible heat radiations are subject to the same laws of reflection and absorption as the visible portions of the sun's radiations, and so it is seen that colour and length of hair will influence the heat absorbed from the sun; light-coloured hair and short, glossy coats reduce the proportion of the sun's heat which is absorbed. Long hair therefore acts adversely on heat balance in European stock by (*a*) reducing the heat lost by radiation, and (*b*) by increasing the heat absorbed from the sun.

It has been pointed out before for East African conditions [2] that the long-haired coat of European types, which was developed as a protection against the cold of northern latitudes, is a distinct disadvantage in hot climates. It is now generally realized that certain grade animals inherit this long-haired character from their European ancestors, that the average coat-length of grade cattle is longer than that of their Zebu parents and that hair length usually increases the higher the animals are bred to the European type. As no East African figures are available to support this general observation it is of interest to observe that in South Africa [1] the weights of hair clipped from Afrikander and Shorthorn cattle of the same live weight were in the proportions of 1 : 10 in summer and 1 : 4 in winter.

Long matted hair is a characteristic of unthrifty grade or pure European stock in the tropics because, apart from their hereditary tendency to grow long hair, the shedding of the calf hair is often considerably delayed and may not take place during the first two years. Bonsma's work [1] has indicated that weaner calves which shed their calf hair early gain weight better, do better generally, and reach sexual maturity earlier than similarly bred calves which do not shed their calf hair in their first summer or which are late in losing their hair.

In an investigation at Mpwapwa a mixed bunch of calves, two years old (differences of a month or two only between the oldest and youngest animals) were fed and managed in exactly the same manner. Every month from two years to three years old, the same patch on the right hump of each beast was shaved of hair and the average lengths of hair growth during the month recorded for each animal. The average length was determined by measuring, with calipers, the lengths of two hundred and fifty hairs from each animal. In this group of animals were included two typical Zebu heifers, three Ankole (Sanga) animals, four three-quarter Ayrshire–one-quarter Zebu (of which one had never shed its calf hair (No. 306), two had typical longish grade hair and one (No. 319) had shorter hair than usual for a high-grade animal), and two three-quarter Friesian–one-quarter Zebu heifers which had

also failed to shed their calf hair. It was hoped to get information which would show whether these long-haired animals showed greater monthly rates of hair growth, after shaving, than short-haired animals, whether animals which retained their calf hair had different rates of hair growth from animals which shed this hair during their first summer, and what differences in hair-growth rates are to be found between the two indigenous types of cattle and the three-quarter grade European animals containing one-quarter of short-horned Zebu blood.

On each animal, a patch the shape of an inverted L was shaved with a razor and the hair discarded. In subsequent months the hair obtained by making a clean sweep with a razor close to the skin was collected for measurement. By this means it was possible to prevent inclusion of hairs which had been cut off at places other than next to the skin. The results obtained are shown in the table, but the hair collected at the first shaving was not measured. Only in the case of the area shaved on the white-haired animal was any sun-burn or blistering caused on the shaved patches.

If the figures for monthly hair growths are plotted it is seen that the curve takes approximately the same shape for each animal irrespective of breed or rate of hair growth. The curve of growth rates can be divided into three portions, (1) from November or December until May or June, during which period the rate of growth remained at roughly the same level for any given animal, though the actual rates varied between different beasts, (2) the period May or June until September, during which time the rate of hair growth was slowed down, and (3) the period September till November or December when the growth rate increased to the level in period (1). Now the periods when the hair-growth rates slowed

Monthly Growth of Hair over a Shaved Area on the Hump (in m.m.)

| No. | Description of hair | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | March |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *306 | Roan calf hair unshed. Very long coat with thick undercoat .. | 10·83 | 10·76 | 10·80 | 10·78 | 10·51 | 10·47 | 10·34 | 10·68 | 11·11 | 11·21 | 11·15 | 11·01 | 10·94 |
| *312 | Dun colour. Calf hair shed. Typical longish grade hair .. .. | 9·50 | 9·67 | 9·80 | 9·77 | 9·20 | 8·49 | 8·75 | 8·97 | 8·70 | 9·22 | 9·18 | 9·21 | 9·42 |
| *317 | White hair. Calf hair shed. Typical longish grade hair .. .. | 9·47 | 9·52 | 9·47 | 9·50 | 8·98 | 8·33 | 8·71 | 9·00 | 9·40 | 9·62 | 9·64 | 9·56 | 9·48 |
| *319 | Red hair rather short for a grade animal. Calf hair shed .. .. | 7·95 | 8·05 | 8·07 | 7·89 | 7·40 | 6·88 | 6·80 | 7·76 | 8·04 | 8·00 | 7·98 | 7·88 | 7·92 |
| †4855 | Grey calf hair unshed. Long matted hair with dense undercoat of shorter hair .. | — | 9·20 | 9·14 | 8·50 | 8·47 | 8·20 | 8·15 | 8·79 | 8·82 | 9·45 | 9·51 | 9·75 | 9·63 |
| †4856 | Grey calf hair unshed. Long outer coat with shorter undercoat .. | — | 9·50 | 9·33 | 9·30 | 8·67 | 8·88 | 8·50 | 8·67 | 8·92 | 9·19 | 9·40 | 9·50 | 9·61 |
| ‡4824 | Short red glossy hair .. .. | 5·95 | 5·92 | 5·87 | 5·94 | 5·28 | 5·23 | 5·11 | 5·24 | 5·53 | 5·60 | 5·55 | 5·68 | 5·85 |
| ‡4849 | Short black glossy hair .. .. | 6·72 | 6·41 | 6·32 | 6·24 | 5·91 | 6·00 | 5·91 | 6·34 | 6·61 | 6·59 | 6·68 | 6·70 | 6·72 |
| §4851 | Short red glossy hair .. .. | 6·35 | 6·36 | 6·38 | 6·46 | 6·15 | 6·07 | 6·01 | 6·20 | 6·39 | 6·62 | 6·32 | 6·31 | 6·47 |
| §4853 | Short dark-red hair .. .. | 6·38 | 6·43 | 6·66 | 6·75 | 6·54 | 6·07 | 6·04 | 6·20 | 6·25 | 6·31 | 6·28 | 6·33 | 6·45 |
| §4854 | Short roan glossy hair .. .. | 6·55 | 6·48 | 6·41 | 6·25 | 5·86 | 6·01 | 5·96 | 6·61 | 6·77 | 6·86 | 6·73 | 6·63 | 6·70 |

*¾ Ayrshire–¼ Zebu. †¾ Friesian–¼ Zebu ‡Zebu §Ankole

down and then accelerated to normal both occurred in the dry season when green food was scarce and so cannot be attributed to this cause. The decrease in hair-growth rates occurred as the average minimum shade temperatures fell below 60°F to their lowest average monthly value in September. The period during which the growth rate returned to normal corresponded to the rise in average monthly minimum temperatures until they reached 60°F in December.

For comparison with the hair-growth rates the average monthly shade minimum and maximum temperatures are given:—

| | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly average shade— | | | | | | | | | | | | | |
| Minimum .. | 62·6 | 62·6 | 60·8 | 59·0 | 59·0 | 59·0 | 57·2 | 59·0 | 59·0 | 60·8 | 60·8 | 60·8 | 64·4 |
| Maximum .. | 82·4 | 80·6 | 75·2 | 75·2 | 78·8 | 78·8 | 82·4 | 84·2 | 86·0 | 87·8 | 82·4 | 86·0 | 82·4 |

It is seen from these figures that the monthly shade maximum temperatures do not appear to be correlated with the curves of hair-growth rates.

It appears that the retention of a longer winter coat is associated with slower hair-growth rates and that the rate of hair growth increases towards the summer level as the animal prepares to shed its warmer winter coat. It is also interesting to note that there appears to be a correlation between the rate of hair growth and the supply of nutrients to the skin. In hot weather the skin blood vessels are dilated and larger volumes of blood are pumped through in an attempt to promote greater cooling of the body by increased radiation from its surface. The opposite effects are produced in cold weather. Thus in the cold season there will be a reduced blood flow through the skin and consequently a smaller supply of nutrient materials than in the hot season and, since the blood nutrient supply to the skin would diminish as the average minimum temperature decreased it may well be that the changes in the rates of hair growth between May and December are determined by the supply of nutrients carried to the skin and that the apparent correlation with average minimum air temperatures is true only in so far as the latter affect the skin's blood supply.

There appears to be significant differences between the rates of hair growth in the indigenous Zebu and Ankole cattle and the rates in three-quarter European–one-quarter Zebu cattle. The grade stock have higher rates of hair growth than the Zebus and Ankoles examined. On the other hand there appears to be little difference between the rates for Zebus and Ankoles, although the Zebu, with short black hair, had lower rates of hair growth than the other indigenous stock examined.

The next point which emerges is that the three-quarter Ayrshire which had not shed its calf hair at two years old and which then had a very long coat showed the greatest rate of hair growth of any animal examined. The two long-horned three-quarter Friesians who had also failed to shed their calf coats, and were typical "teddy bears", showed hair-growth rates which were less than for the long-coated Ayrshire, but corresponded with the rates found for the two three-quarter Ayrshires which had shed their calf hair but which had inherited the long-hair character and had typically long three-quarter grade hair. This may indicate that the Friesian does not transmit such a tendency for rapid hair growth as the Ayrshire and so may be better fitted for life in the tropics than the latter. This is in fact our experience on the coast. The only three-quarter Ayrshire examined which had short hair for a grade animal and which obviously had inherited more of the Zebu hair characters than the Ayrshire's showed a hair-growth rate intermediate between the levels found for the typical longish-haired three-quarter Ayrshires and the indigenous cattle.

It appears that cattle with long hair have greater hair-growth rates than cattle covered with short hair. It is not possible, from the few animals examined, to say whether animals which fail to shed their calf hair in their first two summers are those whose hair grows most rapidly although the three animals examined, which had failed to shed their calf hair in their first two summers, possessed the highest hair-growth rates recorded in the series. It is also possible that the Friesian grades are better suited for tropical conditions because they have a smaller hair-growth rate than Ayrshire grades but this needs further confirmation.

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# EMPIRE PRODUCTION OF DRUGS

## IV—STROPHANTHINUM

By P. J. Greenway, Systematic Botanist, East African Agricultural Research Station, Amani

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According to the British Pharmaceutical Codex "strophanthin is a mixture of glycosides obtained from *Strophanthus Kombe* Oliv. It consists of cymarin, K-strophanthin-B, and other glycosides, and may be isolated from the freshly powdered seeds by extracting first with ether or carbon disulphide to remove fat and then with alcohol, the latter being distilled off, the residue dissolved in water and the solution filtered. The filtrate is treated with tannic acid and the washed precipitate mixed with lead oxide, dried, and extracted with alcohol. On adding excess of ether to the alcoholic solution, strophanthin is precipitated; it is collected, and dried *in vacuo*".

The genus *Strophanthus* is represented by some forty-four species, three in South Africa, thirty-one in Tropical Africa, two in Madagascar, and about twelve in India and the Far East. The species of *Strophanthus* are shrubs or woody climbers with most attractive flowers. Various attempts have been made at Amani to grow the official and other species without much success. Those tried were: *S. caudatus* Kurz, planted 1904, flowered but failed to fruit; *S. grandiflorus* (N.E.Br.) Gilg, planted in 1914, as an East African coastal species no doubt flowered and fruited freely; *S. gratus* (Wall. & Hook.) Franch., planted in 1902, flowered freely and failed to fruit; *S. hispidus* A.P. D.C., planted in 1904, flowered freely; *S. Kombe*, planted in 1910, was not established; and *S. sarmentosus* A.P. DC., in cultivation and flowered in 1908.

The following African species are recorded as having toxic properties, some being used as arrow-poisons:—

West Africa.—*S. gratus*, one of the chief arrow-poisons in the Gaboon and Cameroons; *S. hispidus*, the true arrow-poison plant of West Africa and the only species definitely cultivated by the natives there for that purpose; *S. preussii* Engl. & Pax, believed to be used by the peoples of the Upper Niger region; *S. sarmentosus*, the commonest species in West Africa and predominant in commercial samples of *Strophanthus* from West Africa. It is freely used in some districts as an arrow-poison and is probably quite as effective as *S. hispidus*. *S. ledienii* Stein from the Lower Congo also contains strophanthin.

East Africa.—*S. Kombe*, used as an arrow-poison in Nyasaland, Northern Rhodesia and Portuguese East Africa; *S. Eminii* Asch. & Pax, used as an arrow-poison in Central Tanganyika; *S. Nicholsonii* Holmes, probably used as an arrow-poison in the Luangwa Valley, Northern Rhodesia.

Kombe arrow-poison was first recorded by Livingstone during his Central Africa expedition of 1856. In 1861, Kirk, Livingstone's companion, obtained the seeds from which Kombe arrow-poison was made and proved on himself the power of the poison in slowing down the heart. Through Kirk's action *Strophanthus Kombe* was examined in Edinburgh. It was Fraser in 1885 who first isolated the active principle stropthanthin, and recommended the seeds as a substitute for foxglove leaves. As a result Strophanthin became an accepted drug in the pharmacopoeias of Europe. Subsequently *H. hispidus* and *S. gratus* from West Africa were official in the British Pharmacopoeia up till 1914, but now only *S. Kombe* is accepted. *S. gratus* is still acceptable in Germany; *S. hispidus*, as well as *S. Kombe*, is, I believe, official in the U.S.A.

Strophanthin is preferred to digitalin when the heart is weak. In the body it raises the blood pressure, acts as a diuretic and is a powerful cardiac poison. It is administered by injection either intramuscularly or intravenously. As a poison it paralyses the heart directly and not through the brain and spinal cord.

At the instigation of the Agricultural Department, Tanganyika, the properties of the seeds of *S. Eminii* were investigated by the Imperial Institute, the Rockefeller Institute for Medical Research, New York, and others and it was hoped that the British Pharmacopoeia Commission would make them official. The Commission went thoroughly into the question in 1935 and although they found the pharmacological and therapeutic properties of the seeds and their glycosides to be generally similar to those of *S. Kombe*, in one or two

investigations qualitative differences were indicated. *S. Eminii* seeds give chemical reactions closely resembling those of seeds which it has always been desirable to exclude from official *Strophanthus*. On account of this difficulty and because *S. Kombe* is readily obtainable, the Commission decided not to recognize *S. Eminii* at that time as the equivalent of *S. Kombe*, although *S. Eminii* seeds were acceptable on the continent.

In West Africa some of the species were at one time planted by the natives and traces of these plantations long remained in spite of various official prohibitions. At Bipinde in the Cameroons a plantation of *S. gratus* was started by the botanist Zenker, using *Spondias cytherea* Sonn. as a support for the liane. The avocado pear has also been used as a living support.

It is doubtful if *S. Kombe* will ever be a suitable crop plant for Europeans. In Northern Rhodesia I have found it growing in dry deciduous woodlands in the Luangwa Valley in a climate quite unsuited to European settlement. Its altitudinal range seems to be from sea-level to about 2,000 ft., for it is also recorded from the Dar es Salaam, Kiberege, Kilwa and Usangu districts in Tanganyika; it is common in Nyasaland, in south-east Northern Rhodesia at the confluence of the Luangwa River with the Zambezi and in Portuguese East Africa. It is a deciduous climbing shrub with cymes of short tubular yellowish, red-streaked flowers, the petal-lobes being produced into pendulous strap-shaped tails 3-5 in. long; the fruits are woody, somewhat cigar-shaped, paired follicles which spread at right-angles and are about 15 in. long by 1 in. thick, packed with flattish elliptic-oblong, awned, seeds. The seeds are covered with fine greyish-green to fawn hairs and the awn is terminated by a feathery tuft of long fine hairs, about 2 in. long. The seed, which is about ½ to ¾ in. long, measures, together with its awn, about 4 in.

When the fruits are nearly ripe they are collected, the tip and base of each follicle is cut off and the leathery outer skin peeled, a thin inner skin still covers the seeds. The skinned follicles are then tied with bark string, in pairs side by side, to form a belt 10 in. or more wide not unlike a bandolier and in Nyasaland called a mat. A full mat should contain 42 follicles and in ordinary times a collector is paid up to threepence a mat, though the price has been known to reach sixpence. For export the seeds are stripped from their inner cases and the awns are removed. The collection of *Strophanthus Kombe* seed in Nyasaland is strictly seasonal, ranging from June to the end of August, rarely later.

### British Pharmaceutical Standard.

Strophanthin has to conform to a known potency compared with the international standard ouabain. Strophanthus seed should contain not more than 2 per cent of foreign organic matter and not more than 5 per cent of ash.

The following seeds, which resemble those of *S. Kombe*, have been used as substitutes and as adulterants, but they are not acceptable according to the British Pharmaceutical Standards: *Strophanthus hispidus, S. Courmonti* Sacl., *S. Nicholsonii, S. gratus, S. Eminii* and *S. sarmentosus*.

The strophanthin found in the various species differs: in *S. Kombe* it is designated k-strophanthin, in *S. hispidus* h-strophanthin, etc., and these differences may be the cause of the variation in the drug.

Market Price.—In June, 1941, 100 per cent Kombe seed was quoted on the London market at 10/3 per lb., in New York at \$3.75 to \$4.00. During the four years 1936–1939 the annual amount of *S. Kombe* seeds exported from Nyasaland varied from 14,219 lb. valued at £1,422 to 24,674 lb. valued at £2,467. Should this source ever prove inadequate and the Pharmaceutical Commission decide to make *S. Eminii* official, large quantities of this could be obtained in Central Tanganyika.

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# WHAT THE PLANT DOES WITH ITS MATERIALS*

Most of the organic constituents of plants are formed of carbon, hydrogen, oxygen, nitrogen, and occasionally phosphorus, sulphur and selenium. There is no sound evidence that iodine or bromine is necessary for plants, nor is chlorine apparently essential.

In plants few types of organo-metallic derivatives have been extensively investigated; of these, chlorophyll is the best known. Phosphorus occurs in organic combination in phytin and some other substances. Calcium occurs as pectate and organically bound in agar, yet, generally speaking, the bases are best known in combination with simple organic acids. Iron is essential for plant growth, but beyond saying that it is indispensable for the production of chlorophyll, into the composition of which it does not enter, there is not much that can be said about its role in the plant; nor, except about a very few elements, can much be said regarding the combinations of elements in plants or about the function of their compounds.

Plants have been shown to require, for their proper development, minute amounts of what the agronomist calls "trace" or "minor" elements, meaning thereby elements which until recently were not regarded as necessary, or were even regarded as toxic. The list of necessary elements is now long and is growing. The success of grain formation in cereals grown on some copper-deficient soils of Australia depends upon the uptake by the plants of a few grams of copper per acre. Water from a copper still usually contains enough copper to be toxic if the water is employed for solution cultures; the essentiality of copper is thus a matter of micrograms rather than of milligrams per plant.

The discovery of boron as an essential element for many plants originated in the circumstance that at Rothamsted Experimental Station there was an entomologist who wished to make bean plants distasteful to the black "fly" (aphis) which he was studying. The Botany Department supplied him with some formulae for water-culture solutions to include several unusual elements of which boron was one. All his plants died except those which had been given boron. This was in 1921. The matter was looked into, and in 1923 Dr. Katherine Warington published the proof of the need of the broad bean for boron. It is not given to everyone to found a minor industry with her first piece of research, yet this, in effect, happened in her case. Not only has the agricultural consumption of boron compounds attained considerable dimensions but also the importance of salts of copper, manganese, zinc and other elements as manurial constituents is increasing.

The necessity of zinc for pecan trees on the copper-deficient soils of Florida was discovered owing to a copper solution having been made in a galvanized bucket; only trees treated with this solution (which unintentionally contained zinc) responded. An interesting effect of minor elements was also reported from Florida, where orange trees treated with minor elements in addition to the usual fertilizers suffered much less frost damage than did those receiving customary manuring. This offers an example of the dependence of "condition" upon nutrition. Some minor elements are important for animals though not essential for the herbage plants, which function simply as vehicles. The uptake of cobalt offers an outstanding example of dependence of animals on the soil via the plant.

Plants can be selective in their uptake of elements. From the point of view of essentiality and uptake, one of the most interesting elements is selenium. Its physiological role has been recognized only in the last decade, owing to the investigation of seleniferous soils. These soils have only a small selenium content, but covers vast areas in North America. Marco Polo recorded poisoning of animals in China which has since been shown to be referable to a seleniferous soil. A similar condition in Ireland remains unexplained.

In their reactions to selenium, plants can be divided into four groups: those which require selenium, those which can tolerate large amounts in their tissues, those which can tolerate small amounts but are poisoned by large amounts (these include crop plants such as wheat) and those which practically exclude it. The last group comprises some native prairie grasses. The first group is formed by some species of the botanically varied genera *Astragalus Oonopsis* and *Stanleya*; for these selenium is an essential element, and the concentration in the dry matter and in the seed may surpass 3,000 parts per million. Recently

* Condensed from a lecture given by Dr. Hugh Nicol, Imperial Bureau of Soil Science, as reproduced in *Nature*, 4 July, 1942.

an amino-acid complex containing both selenium and sulphur has been isolated from grain and from Astragalus.

Plants for which selenium is essential, such as certain species of Astragalus, will, of course, grow naturally only on seleniferous soil (the converse does not hold). Hence they serve as an interesting introduction to the subject of "indicator" plants—that is, plants which by their presence or mode of growth indicate soil conditions. The medieval discovery of alum in Italy and the establishment of its manufacture as a Papal monopoly are said to have originated in the finding at Tolfa of a plant supposed to be the same as one which grew near the older alum mines of Asia Minor.

The plant's raw materials are all very simple chemically; unlike to animal, the plant is not adapted for the assimilation or digestion of complex foodstuffs, and if complex materials are presented to the plant they must first be broken down by bacterial or other action before the plant can take them in. The chief role of the soil is to serve as the nidus for such decompositions; weathering for the breakdown of minerals, biological decomposition for the breakdown of plant remains and other organic matter. An important product of decomposition both in the soil and in the tissue of living organisms is carbon dioxide. The only recognized sources of carbon dioxide and indeed of carbon for the plant are the atmospheres above and in the soil.

All plants, even those inhabiting arid regions, are very wasteful of water. For every ton of grain or of dry matter produced, several hundred tons of water are passed through the plant and are discharged as vapour into the atmosphere. The remaining elements are mainly assimilated through the roots, though some for which the plant has only a small requirement can be absorbed through the leaves and stems. Plants are ionic feeders, and they need their ions* as simple as possible.

Intake of nutrients through roots takes place in three ways; direct absorption of anions and cations through the finer roots and root hairs; absorption or exchange of nitrogenous compounds from nodules attached to the roots of many leguminous plants; indirect absorption through the medium of fungi which together with the roots form what are known as mycorrhizae. Recent knowledge about roots has given new perceptions about their extent. T. K. Pavlychenko has measured the roots of single prairie grasses grown free from competition of other plants and has recorded more than three hundred miles of root belonging to a single plant three years old, while a single plant eighty days old had fifty-four miles of roots of first and second order alone. A young plant may have a net gain of the order of one mile of root daily. Roots are neither permanent, as a rule, nor static. The finer roots of a living plant are constantly being shed, and thus are taking part in the cycle of decomposition in the soil. W. S. Rogers has demonstrated the impermanence of roots of such a substantial plant as an apple tree. Within a few weeks apple rootlets have been observed to grow and decay, fresh ones being formed meanwhile in the same region of soil.

There is a balance between the amount of root and the amount of top. By cutting the tops of a plant—say, by mowing the lawn—the roots are also trimmed. A closely cut lawn suffers during a drought because the diminished roots are not able to reach the soil moisture in the deeper layers.

Roots are not merely absorbing organs; they are also reserve organs. The relation between tops and roots has important practical consequences, since if perennial forage plants and grasses are cut or grazed too closely in late autumn they will not be in good condition to survive the winter or to make early growth in spring, on account of the lack of sufficient reserves in the roots. Nitrogenous manures applied in spring are no substitute for adequate over-wintering root reserves.

Leguminous plants may possibly excrete nitrogen fixed by the aid of their associated nodule bacteria, and may thus act as nitrogen "foster-mothers". The dynamics of the plant include several modes of return of absorbed material to the soil. The most obvious in perennial plants is leaf-fall.

The ideal soil is not composed of discrete mineral grains, but of crumbs or aggregates. These include colloidal matter of two kinds—mineral colloids and organic colloids. The latter may be partly humus, which may be regarded as an *end-product* of the microbial decomposition of organic matter. In a fertile soil the organic matter includes a sticky material less inert than humus, and resulting from the recent decomposition of organic matter. This organic

* Certain chemicals in solution dissociate into electrically charged particles called "ions", those with a positive electric charge being "cations", those with negative "anions".

cement sticks the grains together into small crumbs which have the most desirable physical properties. It is not the microbes which are important in soil, but the products of their recent activity are important.

The disposition of materials by plants is a highly dynamic and largely cyclic set of processes. There are, of course, wheels-within-wheels; short-period cycles as well as long-period cycles. The broad cyclicity of nutrients is well shown in the tropical rain forests, where most of the nutrient stock remains, and the greater part of the nutrient cycle takes place, *above* the ground. In cool humid climates the cycle is impeded, and valueless plants such as heather constitute the type vegetation. The ideal agricultural soil is one in which the cycle is fairly shared between soil and plant. Artificial modifications in pursuit of the full roundedness of the soil/plant cycle are the purpose of man's operations in cultivation and manuring.

## USE OF D.D.T. FOR MOSQUITO CONTROL IN THE UNITED STATES

(*A joint statement of policy by the U.S. Army and the U.S. Public Health Service*)

Successful use of the new insecticide D.D.T. to combat insect-borne disease among our troops overseas has brought sudden renown and notoriety to this potent war-developed insect killer. Dramatic reports of its large-scale use to control epidemics, and especially the spraying of D.D.T. from aircraft, have fired public imagination and fostered the hasty conclusion that D.D.T. is a complete solution to all of our insect-borne disease problems. However, it must be remembered that D.D.T. distributed over the countryside not only wipes out malaria-carrying mosquitoes but also may kill other insects, many of which are beneficial. Much still must be learned about the effect of D.D.T. on the balance of nature important to agriculture and wild life before general outdoor application of D.D.T. can be safely employed in this country. It may be necessary to ignore these considerations in war areas where the health of our fighting men is at stake, but in the United States such considerations cannot be neglected.

Extensive investigations are now being carried out by authorized agencies to determine the usefulness and possible hazards in the large-scale dissemination of D.D.T. Until more information has been obtained from such investigations and until it has been evaluated by all interested parties, plans to employ D.D.T. indiscriminately for outdoor area control of insect disease vectors in this country are not to be encouraged.

Since the beginning of mobilization the Army has carried on an extensive anti-mosquito campaign inside of military reservations and the U.S. Public Health Service has maintained a co-operative program for the control of malaria in adjacent extra-military areas. This joint effort has successfully prevented malaria from becoming a problem to troops in this country. To meet the hazard of possible spread of malaria by troops returning from overseas, the Army's program in military areas has been intensified and the program of the U.S. Public Health Service has been extended to include certain additional selected areas in the south where risk of transmission is greatest. Representatives of the Army and the U.S. Public Health Service have given full consideration to ways in which this mosquito control program might be strengthened by employing D.D.T. The following joint policy has been agreed upon pending acquisition of further knowledge concerning the large-scale out-door application of D.D.T.

D.D.T. will be used for residual spray application to houses and other buildings for the purpose of killing adult mosquitoes before they have opportunity to transmit malaria. The long-lasting killing effect of D.D.T. as a residual spray provides a highly effective means to prevent the spread of the malarial parasite. This method of use is safe and economical, and moreover, is welcomed by the householder because it provides freedom from insect annoyance.

The use of D.D.T. as a mosquitolarvicide will be limited to experimental investigations and to situations where D.D.T. has definite advantage over other larvicides in saving materials and manpower, and where it presents no hazard to fish and other wild life.

Distribution of D.D.T. from aircraft for large scale area control of mosquitoes in military and adjacent areas in the United States will be limited to projects conducted with due regard to the possible effects of D.D.T. on beneficial insects and all forms of plant and animal life and in accordance with safeguards established by the Surgeons General of the Army and the U.S. Public Health Service.

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# MINERAL DEFICIENCIES AND EXCESSES IN PASTURES

## A Review

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.), A.R.I.C., Veterinary Laboratory, Mpwapwa, Tanganyika Territory

For those species of live stock whose natural food is pasture herbage, mineral deficiencies are of greater importance than vitamin deficiencies and, since pastures are the raw material on which successful animal husbandry is built and the trade in herbivorous animal products depends, everyone connected with the development of these industries should be familiar with the effects of various pasture deficiencies. It is only by knowing what diseases are produced and how to recognize them that financial losses are to be prevented when opening-up and developing areas such as East Africa.

Miss Russell, in Technical Communication No. 15 of the Imperial Bureau of Animal Nutrition entitled "Minerals in Pastures, Deficiencies and Excesses in relation to Animal Health" has done a very good and timely piece of work in reviewing the literature concerning "those minerals of which naturally occurring deficiency in grazing animals is known or suspected". She deals with the deficiency diseases produced by lack of cobalt, copper, iodine, phosphorus and calcium, reviews the evidence regarding possible deficiencies of sodium, potassium, chlorine and magnesium and summarizes the work on the ill-effects of excessive amounts of selenium, molybdenum, manganese, fluorine and nitrates. For each of these different deficiencies or excesses she gives a general introductory discussion followed by a description of the diseases and a summary of the experimental work which led to a recognition of their causes. This publication should be studied by all interested in the subject but for the benefit of those who cannot obtain it the following brief summary is gvien:

In New Zealand and Australia certain wasting diseases were reported in which cattle and sheep lost their appetite, became emaciated and died of starvation although surrounded by a luxuriant growth of pastures, from the commonly occurring anaemia in these diseases it was found that dosing with iron compounds cured or prevented "bush-sickness" and "enzootic Marasmus". Occasionally no effect was produced by dosing with large quantities of iron whilst at other times good results were obtained with small amounts. Effective iron compounds were then extracted with acid and all the iron removed from solution when it was found that the residues were still curative. Nickel was then suspected as being the required element because it occurred in the residues and a sample of nickel oxide cured the disease. Because cobalt produced polycythaemia in rats, further work was started which proved conclusively that cobalt deficiency was the cause of these wasting diseases and that the iron compounds and sample of nickel oxide used previously had only been effective because they contained traces of cobalt. Subsequent work showed that "Morton Mains Disease", "Mairoa dopiness", "Nutritional Anaemia", "Nakuruitis", "Grand Traverse Disease" and "pining" were all caused by cobalt deficiencies, although certain forms of "pining" were apparently due to parasitism and not cobalt shortage.

It was shown that soils containing less than 2 parts per million of cobalt were likely areas on which cobalt deficiencies in the pastures might be found. The susceptibility of animals to cobalt deficiency varies with the species and pasture containing not more than 0.07 parts per million of cobalt in its dry matter produced diseases in cattle but not in sheep unless the cobalt content fell to 0.04 parts per million or less. Horses were unaffected in areas where sheep died. Cobalt deficiency occurs over a wide range of soil and climatic types but the resultant wasting diseases can be cured by feeding or dosing with cobalt in small quantities or by top-dressing the land with cobalt-salts.

Two other wasting diseases—"Coast disease" of Australia and "Salt-sick" of Florida—affecting sheep, cattle, foals and goats are also characterized by loss of appetite, debility, emaciation and frequently a blanching of the mucous membranes. They are caused by combined copper and cobalt deficiencies and are cured or prevented by dosing with or feeding cobalt and copper.

Cattle, sheep and foals are affected by a deficiency of copper whether caused by a lack of copper in the pastures or produced as a result of other factors interfering with the utilization of copper from pastures containing adequate

amounts. The symptoms of deficiency vary with the place, season and species of animal. "Enzootic ataxia" of Western Australia commonly affects the unweaned lambs of ewes grazing the deficient pastures. They become unthrifty and exhibit a stiff gait which develops into an ataxia when the lambs are driven. The disease usually runs a rapid course, terminating fatally, though lambs which are not affected until 3-4 months old usually survive. Adult sheep show a characteristic "stringy" wool. An enzootic copper deficiency disease of cattle and foals known as "sudden death", characterized by loss of condition, stunted growth, limb abnormalities, suppression of oestrus, evidence of anaemia, depraved appetite and an occasional diarrhoea, is reported from Western Australia. An unusual feature of this disease is that cattle, apparently in good condition, may drop dead suddenly. The number of deaths varies with the season and may reach 5–40 per cent of the herd. Another copper deficiency disease reported from Australia and U.S.A. is "Wobbles" in foals and calves showing the following symptoms: slow growth, unthriftiness, stiff joints and the animals frequently stand on their toes. These diseases are all cured or prevented by feeding the mothers with copper supplements during gestation and lactation.

"Sway back", a disease of young lambs reported from many parts of the world, is a nervous disorder leading to spastic paralysis and inco-ordination of the limbs but no loss of appetite. It usually ends fatally. Work in England suggests that it is not caused by a shortage of copper in the pastures fed to the pregnant and suckling ewes but to interference with the transfer of copper from dam to foetus. The organs of affected lambs and their dams are low in copper whilst the feeding of copper supplements to the ewes has successfully prevented the disease in their progeny. It is thought that a high ratio of calcium to phosphorus or the high lead or zinc contents of the pastures may affect copper utilization.

"Scouring disease" of Holland, in which the chief symptoms are severe diarrhoea, depigmentation of the hair and loss of weight, is cured by feeding copper and cobalt supplements. The organs of affected animals contain less copper than normal but the pastures are not deficient and this disease is presumably another "conditioned" copper deficiency. On the "teart" Somerset pastures another "scouring disease" is found which resembles the Dutch disease above by being characterized by loss of weight and condition, hair depigmentation and severe diarrhoea. It can be cured by feeding copper supplements. The organs of affected animals contain subnormal amounts of copper but the pastures are not deficient. It has been established that, in this Somerset "scouring disease" an excess of molybdenum in the pastures interferes with copper assimilation.

"Licking diseases" have been reported from Holland, Sweden and Germany the chief symptoms of which are loss of appetite, emaciation, enlarged head, general pica and hard mucus-coated faeces. The diseases are prevented by feeding copper in Holland and Sweden, where analyses have shown the pastures are deficient in copper. The "Lecksucht" of Schleswig-Holstein is also cured by feeding copper salts but in this area the small amount of evidence suggests that the pastures are not copper-deficient.

Other "licking diseases" characterized by wasting and depraved appetites in cattle and sheep have been reported from various European countries and some have been attributed to deficiencies of sodium or chlorine or a low sodium to potassium ratio or a deficiency of potassium. South African work on these elements has shown that 1.5 gm. sodium and 5 gm. chlorine daily will suffice for health and growth but that 11gm. sodium and 14 gm. chlorine are required if the cattle are to yield 2 gallons of milk. No "lecksucht" symptoms were produced when the ratio of sodium to potassium was as low as 1:30, whilst other results suggested that a pasture containing 0.34 per cent potassium in its dry matter was sufficient for growth and health but that 0.45 per cent was required if 2 gallons of milk were to be expected. Figures of the composition of pastures from "lecksucht" areas indicate that there is a sufficiency of sodium for all live stock needs except high milk production and enough chlorine for all needs. It has been pointed out however, that in arid and semi-arid areas cattle require larger quantities of sodium and chlorine than in temperate regions and so deficiency of salt may occur. It has also been shown that plant growth will fail before its potassium content can be reduced sufficiently to produce live stock diseases. There is therefore a lack of evidence for the view that deficiencies of or unbalanced intakes of sodium, potassium and chlorine are the causes of these "licking diseases".

"Goitre" in cattle, sheep, goats and horses has been reported from many countries and

from a variety of geological formations though it occurs more frequently on soils rich in calcium or magnesium. The disease is characterized by enlargement of the thyroid and the greater the size of the gland the lower is its iodine content. Iodine administration usually prevents and sometimes controls the disease. "Affected" areas usually have lower iodine contents in their pastures than "healthy" areas but some "healthy" pastures may contain less iodine than "affected" pastures in another district. It has been suggested that deficiencies or excesses of other elements may affect the level at which iodine intake becomes insufficient and results in goitre. No benefit is to be derived from feeding iodized salt licks if no deficiency is involved and evidence suggests that this practice should be avoided in the absence of lack of iodine, particularly if shortages of phosphorus, protein or carotene are to be expected.

Phosphorus deficiency has long been known in certain areas and can be cured by feeding bone meal. Sheep and horses are less likely to suffer from aphosphorosis than cattle. Lack of phosphorus is often associated with insufficiency of proteins and carotene in the pastures and so the clinical picture is often complicated. In areas of abundant sunshine, low phosphorus intakes will lead to bovine rickets but, where there is only little sun a low calcium intake with a low lime:phosphate ratio will also lead to rickets.

There is so far no evidence of a straight acalcicosis in grazing animals though ill-health and bone deformities do occur where there is also a shortage of vitamin D or very little sunshine.

"Grass staggers" and/or "lactation tetany" are two similar diseases of cattle and sheep characterized by nervousness, lack of appetite, high pulse and respiratory rates and hyperexcitability of the neuro-muscular mechanism which may lead to convulsions. Attacks are not always fatal and the incidence of the diseases varies from year to year. Hypomagnesaemia is a feature of these diseases but low serum magnesium values are not always found nor are low serum magnesium values always followed by symptoms of the diseases. Analyses of "affected" pastures do not give sufficient evidence to say definitely that these diseases are caused by a shortage of magnesium in the diet and the exact causes remain obscure.

An excess of selenium in the diet produces serious toxic affects such as "alkali disease" and "blind staggers". The former affects cattle, horses, sheep and pigs and is evidenced by dullness, emaciation, pica, loss of hair from the manes and tails of horses and from the switch of cattle, soreness and sloughing of the hoofs, stiffness of the joints, erosion of the long bones and atrophy of the heart and liver. "Blind staggers" may develop rapidly in cattle and vision is impaired to the extent of almost complete blindness, the animal lachrymates and salivates copiously, grinds its teeth and grunts. There is also a high incidence of anaemia in both diseases.

An excess of molybdenum in pastures leads to severe and persistent scouring in cattle and on the "teart" Somerset pastures interferes with the utilization of copper thereby causing an indirect copper deficiency disease. "Enzootic bovine haematuria" (non-infectious red-water) has been reported from several countries and there is some evidence that it is correlated with pastures with a high content of molybdenum. Top-dressing "affected" pastures with gypsum reduces the uptake of molybdenum by the grasses and is used to control the disease.

"Infectious Anaemia" of horses has been recorded in most countries but has assumed serious economic importance on the forest pastures of Finland and Scandinavia, where it has been found that the pastures are richer than normal in manganese. In the same area "forage anaemia" occurs but differs from "infectious anaemia" in that the horses show no fever nor anaemia but only oedema, emaciation and ataxia which has been attributed to a shortage of vitamin $B_1$. A connexion between the two diseases became apparent when it was shown that horses on $B_1$ deficient diets were more susceptible to the "infectious anaemia" virus. Work with rats has indicated that the feeding of manganese in $B_1$ deficient diet leads to an abnormal retention of manganese by the rats and reduces the time taken to produce avitaminosis.

Excessive intakes of fluorine produces structural deformities in animals but the evidence to date suggests that these are caused more by the drinking of fluorine-containing water and the ingestion of pastures with a surface coating of fluorine-containing dust than as a direct result of eating pastures containing an excess of fluorine in the herbage composition.

"Oat hay poisoning" of cattle causes serious losses in parts of North America and has been shown to result from the ingestion of excessive quantities of nitrates in the oat hay.

# REVIEWS

NOTES ON INSECT DAMAGE TO EAST AFRICAN TIMBERS, by T. W. Kirkpatrick, M.A., F.R.E.S. (Entomologist, E.A. Agric. Res. Inst.), pp. 31; 17 figs. E.A. War Supplies Board; Timber Control, Nairobi, 1944. Sh. 2/50, E.A. Standard.

This publication is the first of its kind in East Africa. It owes its origin to the large increase in insect damage to military timber due to lack of knowledge of timber yard sanitation at the ports and lack of care of timber from the stump site to the port. This lack of care is partly due to the extraction from the forest of species hitherto very little used, about the proper treatment of which there is still ignorance. Similar difficulties were experienced during the last war in the United Kingdom with home produced timber.

The pamphlet deals lucidly with the principal types of timber-borer damage in illustrated sections on (*a*) "Worm Hole", (*b*) "Pinhole" and (*c*)"Powder-post" damage (to page 9). A two-way key in Appendix B provides clues from the character of the damage which bring the responsibility to the various families concerned—as an example of this:—

"9. Surface of the wood apparently sound, the interior with small galleries filled with fine powder . . . incipient attack by Lyctids."

The next eleven pages deal with the insects which cause these three types of damage. This section is illustrated with figures of larval and mature forms as well as with detailed drawings of those parts of the insect body having diagnostic value by which the families may be distinguished. The section is further elaborated by the two-way key in Appendix B by which the families of insects most generally to be found in or damaging timber can be determined.

In the next three pages short notes are given of other pests of timber, i.e. Carpenter Bees, Carpenter Moths, Bark Beetles, Shipworms and Termites. For these last, reference is made to the *E.A. Agric. Journal*, 6, pp. 62–66; 201–205; 8, pp. 146–152, "Termites in East Africa", by W. Victor Harris.

The next four pages are the most important dealing as they do with the *limitation* of the damage caused by worm-borers and Pinhole borers, and the *prevention* of the damage caused by Powder-post beetles. The protection of the tree from the stump site onwards is considered in the first two types of damage and the author stresses common sense and easily applied methods. With regard to injury to standing trees I am reminded of Beeson's observations in India on a worm borer epidemic in standing Sal (*Sharea robusta*) in which he showed the bad practice of blazing trees marked in reserve when thinning. The sap flow to these blazes immediately attracted egg-laying Cerambycids. The Cerambycid found in coppicing mvule stumps may have a similar origin.

The remarks on rapid conversion and open stacking should be read by millers producing box shooks, e.g. of *Antiaris usambarensis*, which can be produced as a clean timber but which is generally seen to be full of pinhole damage.

The appropriate details on the *prevention* of damage by Powder-post beetles should be abstracted by sawmillers, storekeepers, etc., and incorporated in their standing orders. The author states that *all or nearly all powder-post damage is preventable* and that by measures which are no more than common sense. As this type of damage is the most serious particular attention should be given to these recommendations. As a part of these sanitation measures it seems to me that the saw milling industry would derive considerable advantage if it became (like Tanganyika mining companies) "producer-gas-minded". With this source of power they should have cheaper haulage and production costs in using their waste for fuel, not to mention the possibility of producing wood tar and so increasing (for certain purposes) the range of exploitable species. Water seasoning is mentioned as a possible method, which by reducing the starch-sugar content renders the timber unpalatable to Powder-post beetles. This form of seasoning is in general use by the Sukuma people of the Lake Province, Tanganyika Territory, for hut poles of *Acacia fisheri* and *Acacia senegal*. A short immersion in sea water at the ports might have been worth a trial for sleepers. This might be sufficient to kill existing infestations and prevent new ones. Such treatment has increased durability (against fungi) in pit props in English mines. A tentative table of estimated susceptibility to Bostrichids (one of the Powder-post beetles), is given on admittedly too scant information. I would question the high susceptibility ascribed to Gums (*Eucalyptus* spp.) generally and I would also doubt (*pace* Eggeling, "Indigenous Trees of Uganda") the accusation against *Morus lactea* (known as Mkuzufunta in the Amani forests and Mukimbu on Lake Victoria) where it was used for dhow construction and where it has been

reported as lasting over twenty years in the piles of the pier at Nungu Bay.

Much work remains to be done in this matter of protecting timber from insect damage. The first need is for the collection and identification of the insects; the second for the working out of their biology and finally the evolution of simple, good practice to make timber infestation of any kind improbable. Mr. Kirkpatrick's pamphlet is a pioneer in that he has put forward suggestions for the third stage, drawn from the experience of other countries, and it is certainly to the advantage of all saw-millers, timber storekeepers, timber inspectors, builders, forest officers, etc., to take heed of them. L.T.W.

THE SEMEN OF ANIMALS AND ITS USE FOR ARTIFICIAL INSEMINATION: By Dr. James Anderson, B.Sc., Ph.D., M.R.C.V.S., of the Experimental Station, Naivasha, Kenya, pp. 151, illustrated, and obtainable from The Imperial Bureau of Animal Breeding and Genetics, King's Buildings, West Mains Road, Edinburgh 9, Scotland. Price: Sh. 7/6.

This authoritatively written technical communication conforms to the high standard which it is customary to associate with the publications of the Imperial Agricultural Bureaux. It is not possible to do justice to its merits in the short space of a review, suffice to mention that it embraces every aspect of the subject of artificial insemination in animals; it deals with its application to all the various species of domestic animals, foxes and birds, in a most thorough, practical and up-to-date manner, and the supplement carries the work up to 1944.

The scope of the communication embraces a bibliography of some 550 references and it covers a field the width of which may be appreciated from the main chapter headings: Part I. The Semen of Animals; Factors Affecting Semen Production; Physico-Chemical Properties of Semen; Physiology of Semen; Storage and Transport of Semen, and the Examination of Semen. Part II deals with The Artificial Insemination of Animals in many countries, and Part III with the Technique of Artificial Insemination; each of these main headings is most thoroughly examined.

The volume is profoundly technical in character, but it also has the merits of being most readable and interesting to the informed breeder. Dr. Anderson having been responsible for the control and investigation of artificial insemination in Kenya for many years writes with authority, and that this is so will be realized when it is mentioned that 23 per cent of the European-owned cows in Kenya are artificially inseminated. In reference to the Colonial Empire he is of the opinion that artificial insemination will provide a means for the improvement of cattle which probably cannot be achieved in any other way.

Interesting as is the subject matter of the communication readers will have a ready appreciation of the fact that once a farming community, or an African community, has decided to adopt the artificial insemination method of scientific breeding it can only be undertaken with the aid of skilled veterinary control.

In a volume of this sort the difficulties of compiling an index are very considerable, nevertheless the availability of an index would have added greatly to the use of a book which is essentially a valuable work of reference.

E. F. J

RENSEIGNEMENTS CONCERNANT L'ALIMENTATION DU BETAIL LAITIER: By L. Thuriaux and L. A. Lenaerts. Comité Spécial du Katanga, Elizabethville, 1944.

This booklet of 25 pages and one table is written primarily for the farmer, in a simple and direct manner. All the elementary principles that are needed to evaluate a food or balance a diet are plainly stated. The authors emphasize the difficulty in providing the necessary calcium salts, especially for milch cows, when using local Katanga foods, unless one can feed leguminous products. In this connexion it is very interesting to note that wood-ash was found to be a good mineral supplement, not only because of the various trace elements present from the burning of wood, but also because it contains 22 per cent calcium oxide and 1.7 per cent phosphoric acid.

The authors recommend that one ton of hay and 2½ tons of ensilage should be allowed for every good milking cow for use during the dry season when grazing is "parched", and luscious moisture-containing foods are essential to keep up the milk yield.

The statement that an animal is incapable of "fabrique des protéines" is, as regards ruminants, not accurate, as recent studies have shown that the microflora and microfauna of the rumen and reticulum do play an important role in making available for these animals proteins from single nitrogen compounds.

This is a well-written and useful booklet for the local farmer and most of its contents are applicable, not only to the Congo, but to the whole of East Africa. H.S.P.